Model 821B Professional Audio Recorder/Reproducer

Manual

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INTRODUCTION

In the preparation of this operation and maintenance technical manual for the Stephens 821B professional audio recorder/ reproducer, one particular objective has been pursued all the way through: to make it as complete, accurate, understandable and convenient as possible for the user and the maintenance technician. With this objective in view, Stephens Electronics, Inc. welcomes any suggestions for the improvement of the manual, as well as for information regarding errors or omissions. All such correspondence should be addressed to: Stephens Electronics, Inc., 3513 Pacific Avenue, Burbank, California 91505.

The loose-leaf form of this manual permits us to tailor each manual to the exact configuration of the system for which it was issued, thus eliminating much irrelevant and confusing material. It also makes it easy for the user to add or replace various pages with corrected or updated material.

In order to avoid any misunderstanding of certain terms and expressions used throughout the manual, a glossary with definitions is included here. Some of the terms are already familiar to most readers; however, there is no guarantee of universal familiarity with such terms, hence their inclusion in the glossary. Those terms which are peculiar only to an option are defined in a seperate mini-glossary included in the operation section for the option (e.g., the Q-II autolocator).

The recorder/reproducer for which this manual was prepared contains components which are not user servicable! The maintenance section of this manual should be consulted before attempting any repairs or adjustment on this equipment and all warnings noted. Failure to observe these warnings could invalidate the warantee and damage the machine.

GLOSSARY

AUTOLOCATOR: Refers to the Q-II autolocator option, an electronic sub-system integrated with the 821B system for logging and returning automatically to specific tape locations.

AUTO-SYNC: Refers to the 821B control feature wherein the play circuits automatically go into "sync" mode while recording. (See SYNC definition).

DARLINGTON: Term referring to a pair of transistors connected so that the first transistor is an "emitter follower" driving the base of the second transistor; the resulting gain is approximately the product of the two individual transistors' gains.

DYNAMIC CONTROLS: Those pushbuttons/tallies which start and stop tape motion: PLAY, RECORD, STOP, FORWARD, REWIND and LOAD.

HEAD STACK: The assembly of three heads (erase, record, and play) on a mounting plate with electrical connectors and wiring.

MUTE: A playback circuit feature wherein the audio output from a given track is interrupted, although the VU meter for that track will still respond to the playback circuit. Also, the legend on the sync panel and pushbutton for that function.

PRE: Legend on the pushbutton/tally which indicates when the assigned source (input) and mute functions are active.

PUSHBUTTON/TALLY: Combination of a pushbutton switch with a lighted button, in which the light in the button serves as a tally. (See TALLY definition.) The legend on the pushbutton refers to both the switch function and the tally function.

REMOTE ELECTRONICS: Refers to the optional remote control unit which duplicates the assignment controls and tallies on the sync panel.

SCAN: The 60 IPS tape speed mode. Also the legend on the pushbutton/tally which sets and indicates that speed.

SERVO: Expression referring to a "closed loop" system wherein an amplifier drives a motor, the resulting mechanical motion generates a proportional electrical signal. The signal is compared with a standard, and the resulting "error signal" is fed back to the amplifier which then changes the motor drive in a direction which will minimize the "error".

SHUTTLE: A term used to denote tape motion in either direction in all modes. Shuttle controls are those pushbutton switches which start and stop tape motion (dynamic controls).

STATIC CONTROLS: Those pushbuttons/tallies on the tape deck which control power, tape speed, and playback conditions without actually starting or stopping the tape itself: POWER, 30 IPS, SCAN, SYNC, and PRE.

SYNC: Refers to "synchronism" of playback of pre-recorded tracks with simultaneous recording on new tracks. Also the legend on the SYNC pushbutton/tally showing that the "sync" mode is engaged.

SYNC LOCK: An optional feature of the 821B which permits locking the tape speed to an external control instead of the internal crystal control.

SYNC PANEL: Panel in the pedestal above the tape deck, containing the assignment controls and tallies, and the VU meters.

TALLY: A term referring to an indication (tally light or lighted pushbutton) that the corresponding function or mode is actually in effect.

TORQUE: Turning force applied to the reels by the reel motors. Necessary in order to keep correct tension on the tape and to move the tape during play and record modes.

UNIT SERIES (U/S): The series of symbol numbers assigned to the components of a particular electronic assembly. (Explained further in Section 4.0: MAINTENANCE.)

VSO: Stands for variable speed oscillator. The VSO is substituted for the "fixed" speed crystal oscillator whenever it is necessary to adjust the tape speed to some other speed.

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1.0 DESCRIPTION

1.1 GENERAL

1.1.1 FEATURES

The Stephens model 821B professional audio recorder/reproducer is a tape recording and reproducing system of the highest quality, designed to provide recording studios of all kinds with the most reliable, flexible, convenient, and simple multi-channel recording system available. It represents a significant advancement of the art and science of tape recording, as can be seen in the features outlined below.

1.1.1.1

The tape drive is implemented without the use of capstans and pinch rollers, thus eliminating the major source of flutter and of tape and oxide coating wear, and completely removing any speed variations. This is accomplished through the use of two specially designed reel motors operating in a "tight" servo loop, and a precision tape speed sensor digitally phase-locked to a crystal-controlled frequency standard. The use of crystal control assures extremely stable and accurate tape speed, completely independent of power line frequency fluctuation.

1.1.1.2

The tape transport frame is exceptionally rigid and precision ground flat for permanent dimensional stability. This, combined with precise factory alignment and machining of the head assembly components, completely eliminates the need for the user to align the heads. Furthermore, head assemblies may be replaced or interchanged easily, with no mechanical adjustments necessary.

1.1.1.3

In addition to the two normal tape speeds of 15 IPS and 30 IPS, a stable and precisely controllable variable tape speed is provided, adjustable between 10 IPS and 80 IPS by means of a remote control unit. This feature can be invaluable for special effects, pitch changes, etc. An additional fixed speed (SCAN) of 60 IPS is provided, primarily for rapid audible search for recognizable program passages or cue tones in playback operation, but also useable for recording and timing.

1.1.1.4

Individual channel record modes can be assigned or cancelled, and sources (input) pre-selected to the output, by means of a very simple selector switch and five pushbuttons, either locally or at a

remotely located control unit. This eliminates many complicated and space consuming individual switches, and the use of digital logic circuits and multiplexing eliminates much wiring.

1.1.1.5

The optional autolocator works in conjunction with the tape motion sensing idler, determining tape location through the use of a microprocessor. The system includes ten programmable registers for complete search-and-play sequences in any desired order and can be set up to run automatically.

1.1.1.6

There are many other unique features of design and construction less obvious to the operator but none-the-less very important to the system reliability and to the operator's comfort and convenience.

1.1.2 GENERAL DESCRIPTION

1.1.2.1

The tape transport and record/reproduce electronics are housed in a free-standing floor mounted wood cabinet with wood-grain formica finish (pictured at the front of this section). The tape transport is mounted horizontally in the "counter-top" surface of the cabinet, and is completely self-contained, including the tape motion controls and electronics in addition to the bias oscillator, recording amplifiers and playback preamplifiers.

The balance of the record/reproduce electronics are combined with the channel VU meters and the assign system in a seperate electronics group mounted vertically in the pedestal, above and behind the tape transport.

The cabinet dimensions depend on the exact configuration of recorder/reproducer supplied. The tape transport panel surface, set flush into the counter top surface, is 30 inches (74 cm) above the floor for a convenient operating height. The remaining overall dimensions are included in the specifications, Table 1-2.

The cabinet rests on high quality casters, allowing the system to be easily moved about.

1.1.2.2

The main power supply for the system is contained in a seperate unit, as shown in Fig. 1-1, to be situated in a location relatively remote from the tape transport and electronics units. This is done to promote adequate cooling, as well as to minimize hum and other

interference entering the recording and reproducing circuits. The power supply is provided with a 6 ft. interconnecting cable which plugs into the bottom of the tape transport.

Figure 1-1 to be inserted here

Ordinarily, satisfactory operation will be obtained with the power supply installed in the bottom of the cabinet (see Section 2: INSTALLATION). The power supply measures 10 1/2"w x 15"l x 8"h (26.7cm x 38.1cm x 20.3cm), including the carrying handle.

1.1.2.3

The VSO (variable speed oscillator) is housed in a remote control unit, with 6 ft. of interconnecting cable and plugs into the bottom of the tape transport. Its external controls consist of a rotary control knob with a digital readout for precise adjustment of variable tape speed, a switch to select either fixed or variable tape speed, and a meter to indicate relative speeds. This meter is also used to align the speed control circuits as well as indicate stable operation. By itself, this unit is 3 3/4"w x 6 1/4"l x 3"h (9.5cm x 15.9cm x 7.6cm), as shown in Figure 1-2. However, when another remote option is provided, the VSO is integrated into that unit, as described later in this section.

Figure 1-2 to be inserted here

1.2 TAPE TRANSPORT

1.2.1 TRANSPORT MAIN ASSEMBLY

1.2.1.1

The tape transport unit is in the form of an exceptionally rigid, precisely machined one inch thick base plate, mounted on a chassis frame, and set into the counter-top surface of the cabinet. Mounted on the base plate are the reel drive motors and hubs, head stack assembly with tape guides and reverse idler, and the tape drive speed and record/play controls. The base plate is covered with a removeable dress panel. All of the tape drive electronics (except for the optional autolocator remote control) are mounted inside the chassis, accessible from under the chassis when it is tipped up for service. The bias oscillator/amplifier module and all of the record amplifier/playback preamplifier modules for the 16 and 24 track system are mounted on the front of the chassis. These modules are accessible for service and adjustments by pulling open the front of the cabinet and swinging it down. For the 32 and 40 track systems, five of the amplifier modules are front-mounted, and the rest of them are mounted under the transport chassis, and are accessible by tilting up the transport.

The bias and amplifier modules are plug-in units, secured in place by screws. All of the tape motion control modules and active circuit elements are also plug-in.

Dimensions of the tape transport are included in the specifications.

1.2.1.2 TAPE TRANSORT CONTROLS

The tape transport controls are segregated into two separate groups, one on each side of the head stack assembly. The left hand group consists of five lighted alternate action pushbutton switches which control and tally the conditions under which the machine is to operate (power, tape speed, sync, and channel assignment control). The right hand group consists of six lighted momentary pushbutton switches which control and tally the dynamic (shuttle) motion of the tape and the record function (play, record, fast forward, fast rewind, stop and load).

The right hand group of tape controls is duplicated in an optional remote shuttle control, which may be combined with other remote options. The tally lights operate on both controls simultaneously, regardless of which control the last command came from.

The exact functions of these controls are explained in detail in Section 3: OPERATION.

1.2.2 TAPE REELS

1.2.2.1

The Stephens 821B system is designed for use with tape reels having standard NAB hubs, 4 1/2" (11.4cm) diameter. The 821B-103 systems will accomodate reels up to 10 1/2" (26.7cm) diameter. The 821B-104 systems will accomodate reels up to 14" (35.6cm) diameter.

1.3 RECORD/REPRODUCE ELECTRONICS

1.3.1 TRANSPORT MOUNTED MODULES

1.3.1.1

The bias module is constructed on a metal plate which acts also as a heatsink, and includes not only the bias oscillator and buffer amplifier, but also voltage regulators for power to the audio circuits. This is a plug-in module, mounted at the left on the front of the transport, and is identified by part number 2000; it is shown in Figure 1-3.

Figure 1-3 to be inserted here

1.3.1.2

The playback preamplifiers, sync relays, record relays, and recording amplifiers are assembled on plug-in modules, each module encompassing four channels. Thus, a 16-track system utilizes four such modules; a 40-track has ten of them. These modules are identified as type 3100 modules. However, the individual module part numbers are carried as 3101 thru 3110, because the modules have actual channel numbers printed on them; e.g., a number 3101 module panel has channel numbers 1,2,3 and 4 printed on it, a number 3102 panel has 5,6,7 and 8, etc. Otherwise, the modules are identical. This module is shown in Figure 1-4.

Figure 1-4 to be inserted here

1.3.2 ELECTRONICS GROUP - SYNC PANEL

1.3.2.1

The remainder of the record/reproduce electronics elements are housed in a chassis behind and above the tape mechanism. The front panel (sync panel) is hinged, and swings open for access to these elements.

The line input circuitry and the monitor (playback) booster amplifiers are assembled on plug-in cards, each card contains four channels (see Figure 1-5). The cards are mounted inside the chassis, and are identified by the part number 4400.

1.3.2.2

The channel VU meters are mounted in the hinged sync panel. Each meter has its own rectifier and calibration board mounted directly behind the meter.

Figure 1-5 to be inserted here

1.3.2.3

Connectors are mounted in the electronics group chassis, accessible from the rear of the cabinet, for all connections to the electronics group. These include one or more connectors for cables from the transport, one connector for the cable from the remote electronics option when supplied, and two or more connectors for the user's input and output circuits. Adapter cables 6 feet long are supplied for this last application, terminated in XL type connectors for the user's connections.

1.4 LOGIC ELECTRONICS

1.4.1

The all solid-state logic system controls tape motion and speed, selection of assign combinations, relays used for switching some of the audio, and bias record circuits. Audio switching in the line amplifiers annd all EQ switching is done with solid state devices, under control of the logic system.

1.4.2

The individual channel assignment controls and indicators are mounted in the lower portion of the sync panel. These consist of a rotary switch knob for selecting the channel to be assigned, five momentary pushbuttons for assigning the desired conditions, and four LED indicator lights for each channel to show its assigned status. The operation of this function is fully explained in Section 3: OPERATION.

1.4.3

The major portion of the tape motion control circuitry is found on two plug-in cards inside the tape transport chassis, accessible from under the chassis when it is tipped up for service. These are the converter card, part number 10164, and the servo card, part number 10163. The remaining tape motion circuit elements are individually secured to the transport chassis and "permanently" connected to the main wiring harness; however, all "active" elements and relays are "plug-in".

1.4.4

The channel assignment circuitry is located inside the electronics group chassis, on the rear side of the sync panel (hinged door). The LED indicator lights are mounted on a long printed circuit board behind the panel, permanently wired to the harness. All active circuitry is contained in the multiplexer card, plugged into the harness and mounted on the LED card in "piggy back" fashion. This setup is duplicated in the optional remote electronics unit. The multiplexer card is identified by part number 10195.

1.5 POWER SUPPLY

1.5.1

Except for the voltage regulators controlling power for the audio circuits, and a small regulator on the converter card, the power supply circuitry is contained completely within the power supply unit. This is a composite assembly comprising a small, self-contained, self-regulated unit supplying power for the autolocator system (included only when the autolocator option is supplied), and the individual elements for the rest of the system requiring higher power. The regulator circuits for the latter are contained in a plug-in regulator card, part number 10196. The power supply system is more fully explained in Section 4: MAINTENANCE.

1.6 OPTIONS

1.6.1 STANDARD OPTIONS

1.6.1.1

There are a number of optional features available on a "standard option" basis, including various remote control features and a sync-lock feature. The remote functions include:

(1) remote shuttle control
(2) remote electronics (assign controls and indicators)
(3) Q-II automatic tape position locator (autolocator)

1.6.1.2

When optional remote control features are supplied with a system, they are usually combined with the VSO remote control, with some exceptions. Table 1-1 shows the "Standard Option" combinations available and the control box size for each; the dimensions apply in each case with the box resting on a supporting surface with its control panel facing upwards and bottom of panel toward the observer.

VSO	REMOTE SHUTTLE	REMOTE ELECTRONICS	AUTO-LOCATOR	DIMENSIONS, INCHES (CM)		
				WIDE	LONG	HIGH
X	X			7 3/4 (19.7)	5 3/4 (14.6)	3 1/2 (8.9)
X	X		X	7 1/2 (19.1)	10 1/2 (26.7)	3 (7.6)
X	X	X	X	16 (40.6)	9 (22.9)	3 (7.6)
X	X	X		14 1/2 (36.8)	7 (17.8)	3 (7.6)
			X	7 3/4 (19.7)	5 3/4 (14.6)	3 (7.6)

Table 1-1. Remote Combinations and Dimensions

1.6.1.3

All remote control units are supplied with 15 foot interconnecting cables, unless ordered otherwise as a special option. The remote electronics (remote sync panel) circuits are connected to the main system through a connector located in the back of the electronics group chassis. All other remote control circuits go through a

single connector located inside the tape transport chassis (near the power supply connector). Consequently, depending on which combination of remote options is supplied, the interconnecting cable(s) may be split at one end or the other.

1.6.1.4

Any option combination supplied with the system for which this manual is issued is illustrated on the next page (Figure 1-6).

1.6.2 SPECIAL OPTIONS

Special features are available on a custom basis, to meet special requirements of the user. All such special options incorporated in the machine for which this manual is supplied are described in supplementary pages at the end of this section.

1.7 SPECIFICATIONS

1.7.1 MODEL: 821B-104A-24 RECORDER/REPRODUCER

PERFORMANCE

MECHANICAL

Tape Speeds:
15 IPS, crystal controlled, phase locked
30 IPS, crystal controlled, phase locked
60 IPS, crystal controlled, phase locked
10 to 80 IPS, continuously variable, manually controlled

Flutter (RMS):
15 IPS, .045% max.; .03% typ.
30 IPS, .035% max.; .02% typ.

Start Time (Play or Record mode): 1/2 second, max.

Stop Time (Play or Record mode): 1 second, approx.

Rewind Time (2400 feet): 1 minute, approx.

ELECTRICAL

Frequency Response:
15 IPS, +/- 1 dB, 40Hz-15kHz; +/- 2 dB, 25Hz-18kHz.
30 IPS, +/- 1 dB, 50Hz-20kHz; +/- 2 dB, 45Hz-22kHz.

Input Impedance: 10,000 ohms unbalanced, bridging for 600 ohms source.

Input Level: From -10 dBm to +8 dBm.

Output Impedance: Designed to work into load of 600 ohms min.

Output Level: +4 dBm nominal, +24 dBm max.

Signal-to-Noise Ratio:
Referenced to 1040 nWb/m 3% THD; unweighted wideband measured using 250 tape:

Tape Stopped:	77 dB
15 IPS:	71 dB
30 IPS:	72 dB

Bias and Erase Frequency: 204 kHz.

Power Requirement: 125 watts, 110/220 VAC, 50/60 Hz.

PHYSICAL CHARACTERISTICS

Number of Record/Reproduce Channels: 24

Maximum Reel Diameter (NAB hub only): 14 inches (35.6 cm)

Size and Weight:
Cabinet Overall: See Figure 1-7
Component Units (unmounted):

COMPONENT UNIT	DIMENSIONS, INCHES (CM)			WEIGHT LBS (KG)
	WIDTH	DEPTH	HEIGHT	
TRANSPORT	26 (66)	19 (48.3)	12 (30.5)	45 (20.4)
ELECTRONICS GROUP	19 (48.3)	5 (12.7)	12 1/4 (31.1)	15 (6.8)

2.0 INSTALLATION

2.1 GENERAL

2.1.1

Upon receipt from the factory, all equipment should be unpacked and inspected for damage in shipment. Also, the items should be checked against the packing list to verify that all items were received. If any damage or shortage is apparent, immediately report the circumstances to the transportation company and to Stephens Electronics, Inc.

2.1.2

The tape reproducer system is partially disassembled for shipment, and must be reassembled upon receipt at its destination. While this is a simple process, nevertheless considerable care must be exercised in handling and installing the component assemblies to preclude inadvertent damage.

It is particularly important that the tape heads, idler, and tape guides be completely protected while handling and installing the tape transport. The heads are made of relatively soft metal and are easily scratched or dented; the idler is supported on ball bearings of exceptional precision, easily ruined by any sharp blows; all of these elements have a highly finished surface which must be maintained for proper operation.

NEVER ATTEMPT TO LIFT OR MOVE THE TAPE

DECK BY THE HEADS, GUIDES OR IDLER!

2.1.3

A further warning regarding the reel drive motors is in order. These motors are serviceable only by the manufacturer, due to the highly sophisticated design and delicate construction internally. At no time during assembly, installation, operation or maintenance may these motors be opened, cleaned or lubricated. If a motor appears to malfunction, call the factory!

NEVER LUBRICATE, CLEAN OR REMOVE

THE COVER FROM A REEL MOTOR!

2.1.4

When installing the interconnecting cables, make sure that the power supply cable (connector J301) is never plugged into the connector J1405 on the back of the electronics group chassis (sync panel). Should this happen while the power cord of the power supply

is plugged into a power outlet, certain elements in the sync panel will be destroyed instantly. The power cable connector J301 should be plugged into the mating connector P301 inside the transport chassis only.

2.2 ASSEMBLING THE SYSTEM

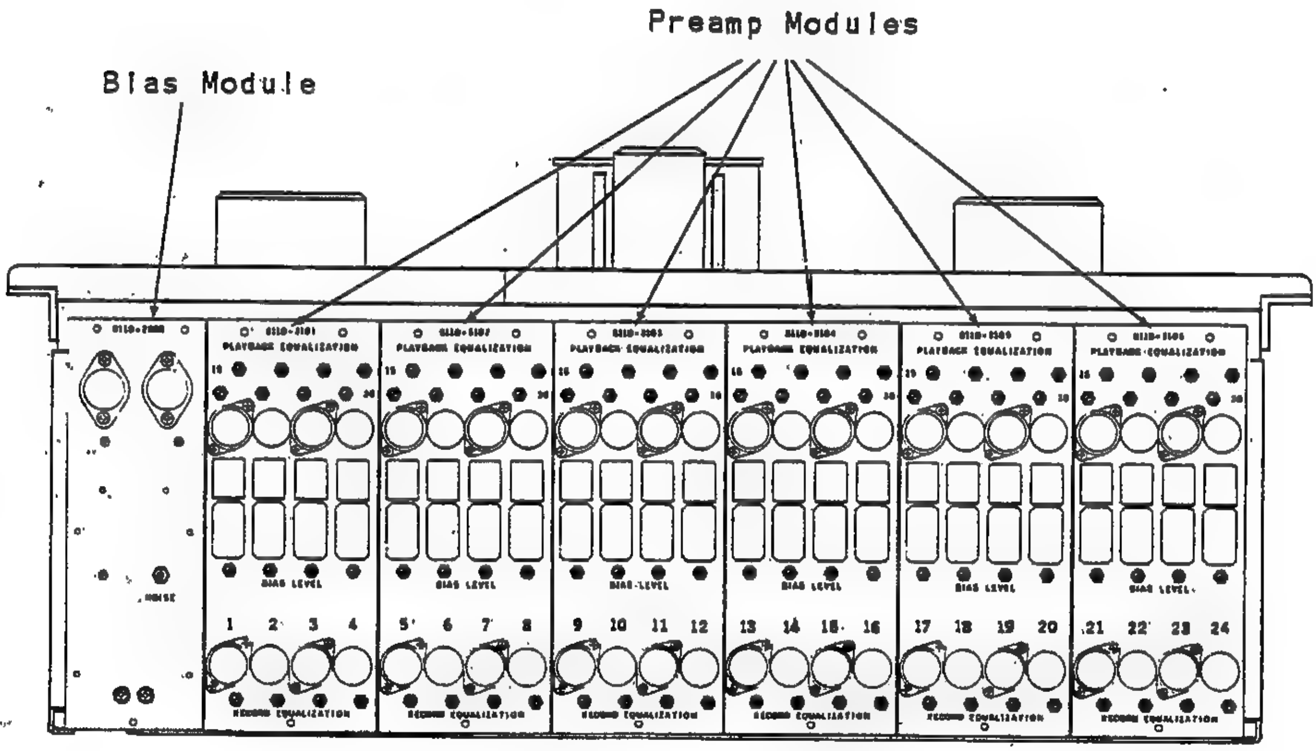
2.2.1

The complete system is normally packed in two crates for shipment. The smaller crate contains the tape transport assembly, with the plug-in components removed. The larger crate contains the rest of the system, including any accessories and optional equipment, as well as the transport items which were removed.

2.2.2

The pedestal portion of the cabinet is stowed in the rear lower part of the cabinet, with the electronic group (sync panel) installed. Remove the pedestal from its stowed position, set it in place atop and at the rear of the lower cabinet. Secure with the nuts, bolts, and washers provided (Figure 2-1).

Figs. 2-1, & 2-2 to be inserted
in this area.



Front view of transport chassis.

FIGURE 2-3. Transport Module Installation, 24 Track.

2.3 EXTERNAL CONNECTIONS

2.3.1 POWER SUPPLY

2.3.1.1

The power supply is provided with a 2-wire primary power cord 6 feet long. When ready to apply power to the system, this cord should be plugged into a 115 volt, 50 or 60 Hz power outlet only. Since the system is not grounded through the power connection, it depends on its connections to other equipment for grounding, which precaution is necessary in order to avoid "ground loops" with their attendant problems in the audio circuits. For safety, the system should be so grounded before application of primary power.

2.3.2

Route the cable from the VSO remote control (or whatever optional remote control unit is supplied) through the opening in the back of the cabinet and up to the transport chassis. Plug the connector P302 into the mating connector J302 mounted inside the chassis on the rear wall, as shown in Figure 2-2.

> NOTE: The VSO must be connected for proper machine operation, even though only fixed-speed operation is desired.

2.3.3

If the remote electronics option is supplied, either separately or combined with other remote options, route its cable behind the cabinet and plug its connector P1405 into the mating connector J1405 on the back of the electronics group chassis, as shown in Figure 2-4.

2.3.3.1

For connection of external input and output audio circuits, split cables are supplied. Each cable assembly is terminated on one end with a multipin connector, and the other end is split into several smaller cables, each terminated in a Switchcraft type A3M or A3F (Cannon XLR type) connector. These cables are 6 feet long unless ordered in other lengths. One cable assembly (W1) is used for configurations up to 16 track, while two cable assemblies (W1 and W2) are used for the 24, 32, and 40 track configuration.

2.3.3.2

The multipin connector(s) P1401 (or P1401 and P1402) should be plugged into the mating connector(s) J1401 (or J1401 and J1402) on the back of the electronics group chassis, as shown in Figure 2-4.

2.2.3

Pull open the front panel on the cabinet and swing it down out of the way. Remove the tape transport assembly from its crate and set it in place in the cabinet top. Slide it forward slightly, and lift the front up to tip the transport up to a vertical position; turn the transport slightly so that it will rest in the upright position. Plug in the relays K1, K2, and K3, and the converter and servo cards inside the transport chassis as shown in Figure 2-2. Install the bias module and the recording amplifier modules at the front of the transport chassis as shown in Figure 2-3.

2.2.4

Set the power supply in place in the bottom rear of the cabinet, route the power cable W101 up to the transport chassis, and plug the cable connector J301 into the connector P301 inside the chassis (Figure 2-2).

2.2.5

Route the cable W302 from inside the transport chassis down below the chassis, out the back of the cabinet, and up to the rear or the electronics group chassis. Plug the connectors P1403 and P1404 into the corresponding connectors J1403 and J1404 as shown in Figure 2-4.

2.3.3.3

The user's connections to his mating audio connectors should be made in accordance with the standard connection sequence as shown in Table 2-1 below:

PIN	CIRCUIT
1	SHIELD (GROUND)
2	AUDIO COMMON (GND)
3	AUDIO HIGH

TABLE 2-1. Audio Cable Connections.

2.3.3.4

The audio connectors on cable W1 (and W2) are in accordance with the industry standard; i.e., the connectors for the recording input to the system are female type (Switchcraft A3F), and the monitor output connectors are male type (Switchcraft A3M). Therefore, the user should terminate his record bus lines in type A3M (cord grip) or D3M (panel mount) connectors or equivalent, and should terminate his monitor input (playback) lines in type A3F (cord grip) or D3F (panel mount) connectors or equivalent.

The recording input circuits are unbalanced (common side grounded), and will accept signal levels from -10 dBm to +8 dBm for a nominal +4 dBm recording level ("0" on the VU meters), adjustable as explained in the paragraphs on alignment. The system input impedance is 10k ohms, resistive. If it is necessary to load the record bus circuits from the console or other source, this should be done externally. usually, a 620 or 680 ohm resistor across each line will work.

The monitor output circuits from the system are unbalanced (common side grounded), low impedance sources, and will work into a load impedance of 600 ohms or higher; additional circuit loading is unnecessary.

2.4 LOCATION

2.4.1

Location of the equipment is generally non-critical, the usual precautions should, of course, be observed, such as keeping the environment dust and grit free, protecting the cables from being walked on or otherwise damaged, etc. The cabinet should not be pushed back tightly against a wall, as this would restrict cooling air flow around the power supply. There should be at least 5 or 6 inches of clearance behind the cabinet. Areas with a strong magnetic hum field should be avoided.

2.5 ALIGNMENT

2.5.1

Upon completion of the installation procedures previously described in this section, perform the alignment procedures described in Section 4: MAINTENANCE, sub-section 4.3, ALIGNMENT PROCEDURES. Since this entails operation of the system, Section 3: OPERATION, should first be studied sufficiently to assure a thorough understanding of the system controls and operation.

3.0 OPERATION

3.1 GENERAL

3.1.1 FOREWORD

3.1.1.1

The main objective of this section of the manual, "operation", is to promote the user's greatest possible realization of the capabilities and convenience of the Stephens 821B Recorder/Reproducer. A full understanding of the control functions and the principles behind them will contribute greatly to such a realization. With this end in view, the specific pre-operating and operating procedures are preceded by a detailed description and explanation of the controls and their functions. The user is urged to read and understand these earlier paragraphs of this section before operating the system.

3.1.1.2

The exact procedures for operating the 821B will depend to some extent on the monitor facilities of the associated audio control console. In the detailed procedures set forth in part 3.4 of this section, it is assumed to be desirable that all console monitoring and studio cue circuit inputs be derived from the 821B outputs, and that primary monitoring of the record channel inputs will be done through the console VU meters. However, if certain features of a particular console make other arrangements preferable, a thorough understanding of all of the 821B's controls will facilitate the formulation of such variations to satisfy the user's needs.

For example, on some consoles, it may be more convenient to switch the monitor sources between tape play and record bus or mute at the console, in which case the 821B assigns could be left in PLAY.

3.1.1.3

A word of caution about the treatment and operation of the machine is in order. The most critical (and most vulnerable!) part of the tape transport mechanism is the assembly comprising heads, idler and tape guides. All of these elements are machined, lapped and finished to a very high degree of precision. Any scarring or other damage on these surfaces will result in the deterioration of quality and service obtainable from the machine.

Dull or rough surfaces on the heads will produce rapid build-up of contamination on the heads, necessitating frequent cleaning; the machine should not be operated in a dusty environment.

A sharp blow on the top of the tape idler can "Brinell" the precision ball bearings and make them run roughly. Or a sideways blow could bend its support and disturb its critical alignment.

So, keep in mind at all times that this is a very fine instrument and treat it with the respect it deserves!

A word of caution also about the reel motors. Never, under any circumstances, should the reel drive motors be lubricated, nor tampered with in any way! This is true even though a slight brush squeak or bearing noise develops. Never even remove the motor cover. Cleaning or applying lubricant to the bearings or brushes will inevitably cause damage and malfunction. If any question arises regarding the motor, call the factory.

3.1.2 CONTROL PHILOSOPHY AND PRINCIPLES

3.1.2.1

The tape control system of the Stephens 821B Recorder/Reproducer is designed to perform as many normal functions automatically as possible, and at the same time to permit a great deal of flexibility. For example, when recording on certain selected tracks, the normal play circuits for the remaining tracks are automatically switched to sync, so that the channels used for monitoring and cueing will not be out of synchronism with those being recorded. However, selected channels can be transferred to source instead, or muted if desired, through the use of the assign feature.

Automatically going to sync when recording does not present any listening quality problem, as the unique design of the recording head and associated circuits results in quality identical to that of the playback head.

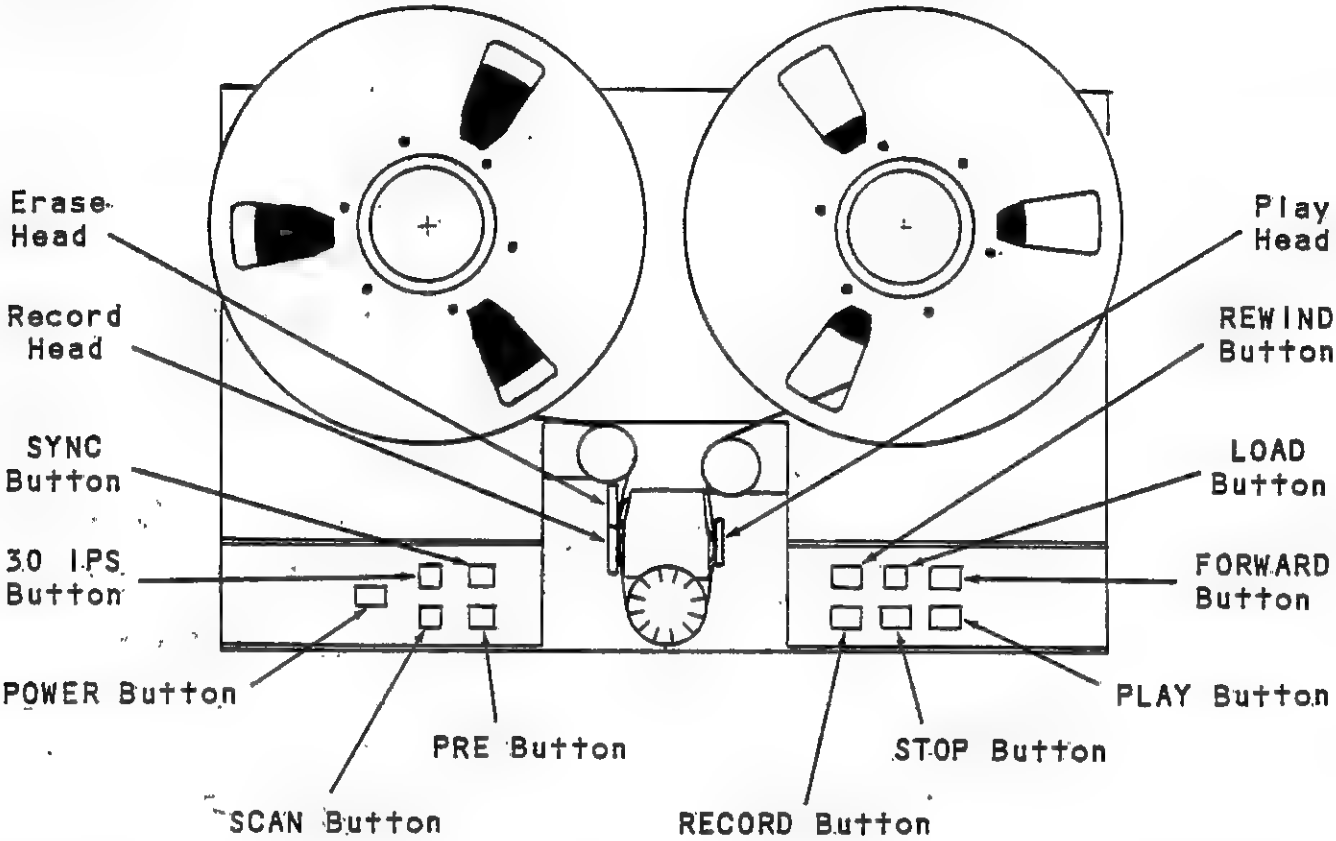
Other flexibilities are designed into the system, as will become evident in the following explanatory paragraphs.

3.1.2.2

The tape system controls are grouped according to functional categories, and consist of pushbutton switches and tally lights. All tape motion controls and "play" master mode controls are located on the tape deck, and the tally for each of these pushbuttons is a light within the button itself. The controls for assigning the individual channel modes are located on the sync panel above the tape deck, and the corresponding tallies for each channel are individual lights.

The tape motion and master mode controls are further separated into two groups, both located near the front edge of the tape deck as shown in Figure 3-1. The left hand group includes those switches which are "static" controls; i.e., those which are normally set once and not changed during a given take or session. These are all "alternate-action" switches (push-on, push-off), and, except for PRE, are not duplicated in any remote options. The right hand

switches comprise the "dynamic controls"; i.e., those which actually start and stop the tape and the recording/playback processes. These are all momentary switches with electronic latching, and are duplicated in various optional remote control units.



The controls for assigning individual channel modes are located on the sync panel, just below the channel VU meters, as shown in Figure 3-2. Because of the large number of switching circuits involved, the controls consist of a single rotary switch (knob) for selecting one channel at a time, and a single set of five momentary push-button switches to engage and electronically latch the desired mode combination for each channel in turn. To the left of these switches are the tally lights, four for each channel, showing the assigned status for each individual channel. All of these controls and tally lights are duplicated in various optional remote control units.

One additional control group is supplied, the VSO (variable speed oscillator). This is always in a seperate, remote unit as explained in Section 1.0, DESCRIPTION. The VSO unit includes:

(1) a variable tape speed control
(2) a switch with which to select fixed- or variable- speed mode
(3) a meter for monitoring the speed- control system.

This control group is not duplicated elsewhere.

3.1.2.3

All push button switches, except for those on the sync panel, incorporate tally lights to show status of the associated functions, the sync panel push-button assignments are tallied by the individual channel lights.

3.2 CONTROL FUNCTIONS

3.2.1 TAPE CONTROLS - STATIC GROUP

3.2.1.1

The left hand group of tape controls, considered "static" since they are usually not changed during operation, includes:

(1) The main POWER on-off switch and its tally light.
(2) A switch to select 15 or 30 IPS tape speed, and its tally light.
(3) An overriding SCAN tape speed switch and its tally light.
(4) A SYNC mode tally light with a switch to override the automatic "sync" mode during playback.
(5) A PRE tally light with a switch to activate the assigned conditions.

These control functions are explained below, and are also tabulated in paragraph 3.2.5: CONTROL SUMMARY TABULATION.

3.2.1.2

The POWER switch controls the system's primary power. Pressing the switch once applies power and illuminates the tally light in its button. The system "wakes up" as follows:

(1) All channel assignments are in NO REC and PLAY configuration (as explained later in paragraph 3.2.3).
(2) The remaining switches in this group are as previously set.
(3) The tape motion mode is either in STOP or LOAD.

Without the optional autolocator, the tape motion will be in "load" mode (explained later in paragraph 3.2.2). The tally is not lighted and no torque is applied to the reels; they will remain motionless with or without tape.

With the autolocator option installed, the tape motion mode will be "stop" (with the STOP tally lighted), which applies low torque to both reels. With tape threaded normally, no tape motion will occur; without tape, the reels will rotate slowly in opposite directions, which can be stopped by pressing the LOAD button.

3.2.1.3

With neither the 30 IPS nor the SCAN switch on, the tape speed is 15 IPS when in play or record mode. Pressing the 30 IPS switch once will change this to 30 IPS, and its tally light will indicate the "30 IPS" condition. The tally stays on regardless of the dynamic tape mode; this control is effective only in "play" or "record". Pressing the switch again will turn off the tally light, and the play/record speed reverts to 15 IPS.

The 30 IPS switch also changes the equalization to correspond to the tape speed selected.

3.2.1.4

The "SCAN" speed function will override the 15/30 IPS control, and is used normally for a rapid search of a recorded tape to find, audibly, a certain position or passage, or for timing. Pressing the SCAN switch once will generate a tape speed of 60 IPS when in "play" or "record" mode, regardless of the 30 IPS control setting, and the SCAN tally light will indicate this condition. (The 30 IPS light will remain on or off, even though that control is overridden by SCAN.) Pressing the SCAN button again will turn it off, its light will go out, and control will revert to the 30 IPS switch setting.

The equalization is not changed when SCAN is engaged, but remains in whichever status is determined by the position of the 30 IPS switch.

3.2.1.5

Both the SYNC and PRE switches may be regarded as a form of master control for the "play" mode of operation. The preassigned monitor sources are automatically in effect in all modes (including STOP) except for "play" mode. When the machine is in "play", the PRE switch will determine whether the monitor source is the tape (PRE switch off), or the preassigned source or MUTE (PRE switch on).

The "sync" function (explained in paragraph 3.2.1.7) is automatically engaged only when the machine is in "record" mode; in all other modes, the SYNC switch determines whether or not "sync" is engaged.

3.2.1.6

The "PRE" (preassign) function sets into operation the various monitor (recorder output) modes which have been selected at the sync panel for each individual channel (as explained later in paragraph 3.2.3). This is done in all tape modes except "play", and is also true of "play" mode if the PRE switch has been actuated. The PRE tally light is on whenever the assign function is engaged, whether automatically or through the switch. When PRE is off, in the "play" mode, the monitor source is the playback circuit for all channels (playback head, or record head if "sync" is engaged).

The PRE switch is the only one in the left hand group which might be duplicated elsewhere. When the Remote Electronics option is supplied, in either of its configurations, it includes its own PRE switch and tally. Either of the PRE switches will engage the assign function in "play" mode, and will light both tally lights. To

disengage the assign function in "play", both PRE switches must be off, and both tally lights will be extinguished.

3.2.1.7

The term "SYNC" is an abbreviation of the word "synchronism". The purpose of the "sync" function is to make it possible to listen to certain pre-recorded tracks as an accompaniement for recording additional tracks in synchronism with the original tracks. This is done by using the pre-recorded track record head as a playback head, with no sacrifice in quality. (The normal playback head is not synchronized with the record head, and cannot be used for this purpose.)

With one exception, (paragraph 3.2.1.8), the "sync" function transfers all "play" channels from the playback (reproduce) head to the record head. This is done automatically in the "record" mode, and is also true of the other modes if the SYNC switch has been actuated. The SYNC tally light is on whenever the play circuits are in "sync", whether automatically or through the switch.

Note that this monitor source prevails only for channels assigned for "play"; it does not apply to channels assigned to either MUTE or SOURCE if the PRE tally is lighted.

3.2.1.8

The exception mentioned above occurs while recording. Obviously, recording on a given track makes that particular record head circuit unsuitable for playback; therefore, any channel which is actually recording has its play source switched back to the playback head. This, of course, puts it out of synchronism with the other channels, and consequently it is advisable to assign that channel to SOURCE or MUTE as described later.

3.2.2 TAPE CONTROLS - DYNAMIC GROUP

3.2.2.1

The right hand group of tape controls, commonly called "shuttle controls", is considered "dynamic" since they control the actual tape movement. This group includes PLAY, RECORD, STOP, FORWARD, REWIND, and LOAD push button switches, with tally lights incorporated. These control functions are explained below, and are also tabulated in paragraph 3.2.5: CONTROL SUMMARY TABULATION.

The tape motion can be changed from any mode directly to any other mode, by pressing the appropriate button or butons (except as noted in paragraph 3.2.2.3).

The dynamic tape controls are duplicated in the optional remote shuttle control when supplied. Dynamic tape modes or mode changes

can be initiated from either control, regardless of where the previous command came from.

3.2.2.2

The "STOP" function may be engaged while in any other mode, and serves to bring tape motion to a safe, controlled stop. The manner in which it does so entails a departure from older, more conventional machines, as explained below.

Tape motion in the Stephens system is accomplished without capstans and pinch rollers, by precise control of power to the reel motors. In order to maintain proper tape tension at all times, these motors must have torque applied to them continuously, even in the stopped position, and therefore there are no static (friction) brakes on them. Stopping is accomplished by increasing the reverse torque on the feed reel motor, and reducing the torque on the takeup reel. As soon as the tape stops, both torques are reduced to a low holding value. The tape lifters are actuated while stopping, and remain actuated until the tape comes to a stop.

One precaution should be observed when stopping the tape. Should the tape run completely off either reel, pushing STOP will cause both reels to rotate at high speed, in opposite directions, because of this torque; therefore, push the LOAD button instead; this removes all torque (as explained below) and permits the reels to be stopped by hand.

With this one exception, stopping tape motion is always done with the STOP button.

3.2.2.3

The "LOAD" function removes all torque from both reel motors, and leaves them free to be turned by hand. This feature is used not only to unload or to load and thread the tape on the machine, but also for editing.

The "play" audio electronics continue to function in all tape modes except "record". Thus, going into "load" mode allows you to move the tape slowly by hand while listening for a precise location on the tape. Furthermore, holding LOAD and pressing RECORD and PLAY simultaneously puts the electronics in "record" mode, so that you can move the tape by hand to erase precise portions of a track.

To release the "record" function and remain in the "load" mode simply press and release either the PLAY or RECORD button by itself. However, to release the "load/play" or "load/record" mode completely, it is necessary to press STOP, FORWARD or REWIND.

> CAUTION: Do not press LOAD when tape is running normally, expecially in FORWARD or REWIND, as the removal of torque under these conditions

can easily result in spilled tape.

3.2.2.4

The "PLAY" function does two things:

(1) It starts the tape moving at the speed determined by the static controls (paragraph 3.2.1)
(2) It interrupts the assign function and reroutes it through the PRE switch.

3.2.2.5

The primary function of the "RECORD" switch is to actuate the selected record circuits and to start the overall recording process. However, pressing RECORD by itself will not do this, as it is electrically interlocked to prevent accidental erasure. To start recording, it is necessary to press PLAY and RECORD simultaneously (whether or not already running in "play" mode); it does not matter which one is pressed first or released first.

When the machine is operating in "record" mode, momentarily pressing either RECORD or PLAY will cause it to revert to "play" mode without interrupting the tape motion.

As described in paragraph 3.2.2.3, the "record" mode audio functions can be engaged while holding the tape in "load" (motionless) mode. When in this "load/record" mode, momentarily pressing either RECORD or PLAY will cause it to revert to the combined "load/play" mode.

3.2.2.6

The "FORWARD" and "REWIND" functions provide for fast tape shuttling. Either of these modes can be engaged at any time, and from any other mode. During the fast shuttle tape movement, the tape lifters are energized, to avoid unnecessary head wear and excessive audio level.

As mentioned in paragraph 3.2.2.2, a fast shuttle should be terminated by pressing STOP or PLAY, unless the tape has run completely off one reel; in which case, LOAD should be pressed and the reels stopped by hand.

3.2.3 CHANNEL ASSIGNMENT CONTROLS

3.2.3.1

On the "sync panel" (front panel of the electronics group), below the VU meters, are the controls and indicators for determining the operating conditions of the record and playback circuits on an

individual channel basis. These controls and indicators are duplicated in the Remote Electronics option when used; either set of controls can be used to set or change and assignment regardless of which one issued the previous command, and both sets of indicators will show the current status continuously. A "select and engage" system is used, wherein a rotary switch is turned to the desired channel position, and the desired assigned conditions are then set by pressing the corresponding push buttons. This set of five buttons does not include tally lights, since status is shown individually for each channel. The sync panel controls and indicators are shown in Figure 3-2.

3.2.3.2

The top row of lights (green) indicates which channel the selector switch is turned to. If the system includes a Remote Electronics package, there may be two lights on at a time. Since this row of lights responds to both selector switches, it might be desirable to rotate one of the switches to identify which position that switch is in.

The second row of lights (red) indicates recording status; if a red light is on for a given channel, that channel will record when the tape deck is placed in "record" mode. These lights are on for both "ready" and "recording" status. With the channel selector switch in a given position--e.g. channel 6, pressing the red REC button will place channel 6 in "record-ready", or, if the tape is already moving in "record" mode, will place channel 6 in "record". Conversely, pressing the white NO REC button will drop out channel 6 from the "record" or "record-ready" status (this is sometimes called "safe"). This row of red RECORD indicators refers only to "record" mode, and has nothing to do with any of the output preselected modes.

3.2.3.3.

The remaining buttons and indicators apply only to the tape output functions. For example, with the channel selector is position 6, pressing the orange SOURCE button will light the channel 6 SOURCE (INPUT) green light - 3rd row of indicators. In this condition, channel 6 will output whatever signal is being fed to its recording input; whenever the PRE tally is lighted. If the PRE tally is unlighted, the output will come from the playback circuits. Under the same conditions, assigning "mute" by pressing the yellow MUTE button will keep that channel output muted. This condition will be shown by the bottom lighted yellow LED for that channel (which, as before, stays on even when PRE is unlighted). At the same time, the VU meter for that channel will respond to the signal from the tape.

Pressing the PLAY assign button will extinguish both the SOURCE and MUTE indicators for that channel.

3.2.3.4

Perhaps it should be emphasized here that, as explained in paragraph 3.2.1.8, any channel that is recording reconnects its playback circuit to the playback head, which puts it out of synchronism with the rest of the tracks. For this reason, the monitor should be assigned to SOURCE whenever the channel is assigned to RECORD, if it is necessary to monitor that channel while recording. As an alternative, assigning MUTE instead will silence the output of that channel, while the VU meter will respond to the playback head and verify that the channel is recording.

3.2.4 VSO FUNCTIONS

3.2.4.1

In normal use, the VSO serves mainly to monitor the operation of the tape speed control circuits, to assure that its phase-locked loop system is operating properly. When it becomes desirable to move the tape at speeds other than the crystal-controlled speeds of 15, 30 or 60 IPS, the VSO unit comes into play as a tape speed control. Moving the NORMAL/VSO toggle switch to VSO puts the variable speed control into operation, and lights a red warning tally light.

3.2.4.2

Variable tape speed is controlled by means of a knob with digital readout, by which the speed can be adjusted above or below the nominal fixed speed set by the static controls. If the fixed speed is set for 15 IPS, the variable control can be adjusted to any speed between 10 and 20 IPS; if set for 30 IPS fixed speed, it can be adjusted between 20 and 40 IPS; and at "scan" speed (60 IPS fixed), the adjustment range is 40 to 80 IPS.

There is no provision for measuring or indicating the exact tape speed while under VSO control. The important feature is a precise repeatability of any given speed, with a resolution of about 1/10%.

In use, the variable speed is adjusted as precisely as required in response to some external parameter, such as musical pitch, or program timing, or synchronism with other program material, etc. Once the speed adjustment has been made, the digital reading above the control knob can be logged, so that the same exact speed can be repeated if necessary at some later time. The digital readout will be from 001 to 999.

When running the tape at some variable speed close to a selected fixed speed, the meter pointer will swing from side to side. The closer the variable speed is to that fixed speed, the more slowly the pointer will swing. This meter action can serve as an aid in estimating the true tape speed when in variable speed mode.

3.2.4.3

Moving the toggle switch back to NORMAL restores fixed speed operation, and the variable control no longer has any effect. It also extinguishes the red warning light.

3.2.4.4

Initial adjustments within the VSO unit and resulting meter response are explained in Section 4.0: MAINTENANCE.

3.3 PRE-OPERATING PROCEDURES

3.3.1 GENERAL

3.3.1.1

Pre-operating procedures include those activities required to prepare the system for actual recording or playback operations. Different conditions will dictate different degrees of preparation. Listed below are all such procedures as would be required with a newly installed system, or after a substantial period of use when assurance of full capability is desired. In following these procedures, any of them which have already been performed or are not needed may be omitted.

3.3.1.2

When re-using tape which has been previously used, especially on another machine, it is advisable to bulk-erase the tape first. This will assure complete erasure of old recorded tracks.

3.3.2 OPERATING PROCEDURES

3.3.2.1 ELECTRONIC ALIGNMENT.

Perform the electronic alignment procedures as described in Section 4.0: MAINTENANCE. It is particularly desirable to adjust bias level and record level whenever changing the type of tape used.

Even if alignment is not required, the heads should be demagnetized with power off and cleaned, before loading and threading a new reel of tape.

3.3.2.2 POWER.

Press the POWER button once; the tally will light.

3.3.2.3 PREPARE FOR LOADING.

If tape has not been threaded, press LOAD. Tally will light. (If tape is already threaded, press STOP.)

3.3.2.4 SAFE.

Make sure none of the red "RECORD" tallies on the sync panel are lighted. A convenient way to clear all recording circuits is to hold down the NO REC button while rotating the selector switch through all positions (one complete revolution).

Figure 3-3 to be inserted here or
above note below

3.3.2.5 THREAD TAPE.

Press LOAD (if not already in "load" mode). Put reel of tape in place (supply reel at left), rotate until it drops down over the hub and press down past detents until it seats solidly against the hub base. (NOTE: use reels with NAB hubs only.) Thread the tape as shown in Figure 3-3; make sure the tape is outside the tape lifters, and inside the magnetic shields. (The shields may be swung out for threading if necessary.) Anchor the free end of the tape in the takeup reel on the right; hold the end of the tape against the reel hub and give the reel two or three turns to anchor the tape to it.

> CAUTION: Do not bend or double over the end of the tape to anchor it, as any bump in the reeled tape may cause wow in the recording or reproduction!

After threading, press STOP; tally will light, and reels will come to rest with a light tension on the tape.

3.3.2.6 TAPE SPEED.

Set desired tape speed for recording (or speed at which tape was recorded if for playback), with 30 IPS button; tally is lighted for 30 IPS, or tally is off for 15 IPS. (If 60 IPS is desired, press SCAN.)

3.4 OPERATING PROCEDURES

These operating procedures should be followed only after the pre-operating procedures have been completed. (See sub-section 3.3.)

3.4.1 FAST FORWARD.

A. To transfer tape rapidly from the supply reel to the takeup reel, press FORWARD. This may be initiated from any other mode.

B. To stop fast forward, press STOP. If tape runs completely off the supply reel, press LOAD and stop reels by hand.

3.4.2 FAST REWIND.

A. To transfer tape rapidly from the takeup reel to the supply reel, press REWIND. This may be initiated from any other mode.

B. To stop fast rewind, press STOP. If tape runs completely off the takeup reel, press LOAD and stop reels by hand.

> NOTE: In either fast shuttle mode, tape lifters hold the tape away from the heads to avoid excessive headwear and playback level.

3.4.3 PLAYBACK.

A. Press PLAY to start tape moving at selected speed; tally will light. If "PRE" tally is lighted, press PRE once to turn it off if not wanted. If "SYNC" tally is not lighted, playback is from playback head; if "SYNC" tally is lighted, playback is from record head, and can be transferred by pressing sync once. Note that playback from either head is of full quality.

B. To stop "play", press STOP. If tape runs completely off supply reel, press LOAD.

3.4.4 RECORDING

3.4.4.1 RECORDING ORIGINAL TRACKS.

A. Unless previous selection of recording channels is to be repeated, clear all channels (safe) by pressing the NO REC button while rotating the channel selector through all channels (one full revolution). Then rotate channel selector to each channel to be recorded, and press REC and SOURCE (INPUT) assignment buttons momentarily at each such position. The tally lights under each channel will verify the status.

B. Apply program material to be recorded, or similar test signals, and adjust signals for proper recording levels.

C. When ready to record, press PLAY and RECORD buttons simultaneously, and release. Both tallies will light, tape will move at selected speed and selected tracks will record.

D. Press STOP button to end recording and stop tape motion. If tape runs completely off supply reel, press LOAD.

3.4.4.2 RECORDING ADDITIONAL TRACKS (OVERDUB).

A. Clear all channels by pressing NO REC and PLAY assign buttons while rotating the channel selector through all channels (one full revolution).

B. Set channel selector to each new channel to be recorded, one at a time, and press REC and SOURCE (INPUT) momentarily at each such position. The tally lights under each channel number will verify the status.

> NOTE: If audio output is not desired from any track (recording or pre-recorded) while overdubbing, set channel selector to each such channel and press MUTE for each such position. The VU meters for those channels which are recording will respond to playback head outputs, and those channels not recording will respond to sync (record head) outputs.

C. Engage "sync"; press the SYNC button once if necessary; tally should be lighted.

D. When ready to record, press PLAY and RECORD buttons simultaneously, and release. Both tallies will light, tape will move at selected speed, and selected tracks will be recording.

> NOTE: If "punch-in" recording is desired, turn on SYNC, start tape moving in "playback" by pressing PLAY, and listen for cue. Hold PLAY down and, at the instant recording is to begin, press RECORD, then release both buttons. Both tallies will be lighted, and selected tracks will be recording.

E. To end recording and tape motion together, press STOP. If tape has run completely off supply reel, press LOAD.

> NOTE: If it is desired to end recording of that segment but continue in playback mode without interruption, press the PLAY button at the stopping point. Then to stop playback and tape motion later, press STOP. If tape runs off supply reel, press LOAD.

3.4.5 SELECTIVE ERASURE (EDITING).

This procedure is applicable where it is desired to erase a certain definable portion of a recorded track or tracks.

3.4.5.1 ERASURE PROCEDURES.

A. Clear all channels by pressing NO REC and PLAY assign buttons while rotating the channel selector through all channels (one full revolution).

B. Engage "sync"; press the SYNC button once if necessary; tally should be lighted.

C. Run tape in "play" mode if necessary, to locate passage to be erased. Stop tape as close to the beginning of the passage as possible. Flip the magnetic shield out of the way, and mark the tape at the record head with a grease pencil (china marking pencil).

> NOTE: If the start of the erasure must be located more precisely than is feasable with STEP C, perform STEP D; otherwise, skip to STEP E.

D. Press LOAD. Move tape manually by hand-turning the reels, to locate the precise starting point, then mark that point on the tape at the record head gap with a grease pencil. Press STOP.

> NOTE: Keep the tape under light tension while moving it manually.

E. Run tape in "play" mode if necessary, to locate the end of the passage to be erased, and stop the tape at this location. If necessary, repeat Step D to locate the end of passage precisely. Leave machine in "load" mode.

F. Manually back up the tape until the start mark is aligned with the erase head gap.

G. At sync panel, set selector switch to the channel (or channels, one at a time) to be erased, and press REC at each such position. The red tally(s) for the channel(s) to be erased will light.

H. Press and hold LOAD and PLAY and press RECORD, then release

both buttons. Machine is now in the "load/record" mode. Manually advance tape by turning the takeup reel, keeping a light tension on the tape by braking the supply reel by hand. Advance the tape slowly until the stop mark arrives at the erase head gap, and stop. Press STOP. Erasure is now complete.

> NOTE: If the starting point of the erasure must be more sharply defined than 1/30 second for 30 IPS (or 1/15 second for 15 IPS), any concern about partial erasure by the record head can be eliminated by sticking a length of splicing tape over the record head gaps after STEP E is completed. When erasure is completed, remove the tape from the head gaps and clean the record head to remove any residue.

3.4.6 VARIABLE TAPE SPEED

3.4.6.1

This procedure applies when it is necessary to operate at other than fixed tape speeds (15, 30 or 60 IPS).

A. Set the tape deck controls for the fixed speed nearest the desired speed; i.e., 15 IPS, 30 IPS, or 60 IPS (SCAN).

B. On VSO unit, move the toggle switch to the "VSO" position. Red tally will light.

C. Start tape moving (play), and adjust the ten-turn speed control knob on the VSO unit for the exact speed desired.

> NOTE: Exact tape speed is not directly measured or indicated in the 821B. However, the speed control constitutes a precise, fine control of speed with excellent stability and repeatability, and its position is accurately indicated by the digital readout above the knob. If you cannot reach the desired speed, simply set the next speed on the fixed-speed switches on the tape deck, and readjust the speed control.

If the desired (variable) speed is very close to the fixed speed setting as determined by the 30 IPS or SCAN switch, the VSO meter pointer will swing from side to side. If it swings and returns once per second for example, the actual tape speed is 61/60 or 59/60 of the speed set by the switches; two complete swings per second would equal 62/60 or 58/60, etc. Thus, by observing the meter action, you can often estimate actual tape speed.

D. Log the reading in the digital readout window directly above the knob, for future reference in resetting to the same speed.

E. To return to fixed speed operation, move the toggle switch back to the NORMAL position. Red tally will be extinguished.

3.4.7 OPTIONAL EQUIPMENT.

Operating procedures which are required for equipment or modifications classified as options will be found in this sub-section, if such options or modifications are supplied as part of the 821B system for which this manual is issued.

4.0 MAINTENANCE

4.1 GENERAL

4.1.1

This section of the manual is divided into five general categories:

- Preventive Maintenance and Precautions
- Alignment Procedures
- Corrective Maintenance (Trouble-shooting and Repairs)
- Performance Tests
- Theory of Operation

This last section is not intended to be a comprehensive analysis of the design of the system; it is included primarily to help maintenance technicians understand how the system works, so that they can readily identify the cause of a malfunction and correct it.

4.1.2 PARTS IDENTIFICATION

In order to facilitate the identification and locations of the component electrical and electronic parts of this equipment, a system of symbols is used. These symbols are used in the schematic diagrams, the parts lists, and in some cases on the parts and assemblies themselves. When consulting the factory or other service organizations regarding parts or problems, references to these symbols to identify the specific items will help avoid ambiguities which can otherwise occur.

Each integral assembly, such as chassis, PC board, switch group sub-assembly, head stack assembly, etc., is identified by a "UNIT SERIES" number, starting with 100, 200, 300, etc. Within each unit series, the individual component parts are identified by the appropriate prefix, the unit series, and the component number serially. For example, for unit series 700, transistors are Q701, Q702, etc.; capacitors are C701, C702, etc.

For any chassis or unit which has or will possibly have more than 99 of any component, two or more successive unit series are assigned. Component prefixes are assigned as shown in Table 4.1-1, Circuit Element Identification; unit series numbers are listed in Table 4.1-2, Unit Series Assignments.

PREFIX	DESCRIPTION
A	Amplifier
B	Motor or solenoid actuator
C	Capacitor
D	Diode, rectifier or zener or photo
E	Individual screw terminal or stud
F	Fuse
I	Indicator
J	Jack or female connector
K	Relay
L	Inductor or choke
M	Meter
P	Plug or male connector
Q	Transistor
R	Resistor, fixed or variable
S	Switch, manual or stepping
T	Transformer
V	Vacuum tube
W	Electrical cable
Y	Crystal (piezoelectric resonator)
Z	Filter or special passive network
CB	Circuit breaker
IC	Integrated circuit (except amplifier)
PS	Power supply assembly
TB	Terminal board or multiple tie point
TP	Test point
X()	Socket; e.g., XQ301 = socket for Q301

TABLE 4.1-1. Circuit Element Identification.

UNIT SERIES ASSIGNMENTS

SERIES	ASSIGNMENT
(None)	External Cables only (connectors at both ends)
0100	Power Supply Chassis
0200	Power Supply Regulator card
0300	Tape Transport Chassis
0400	Left Hand Switch Group
0500	Right Hand Switch Group
0600	Head Assembly
0700	Converter Card
0800	Servo Card
0900	Bias Oscillator Module
1000	Record Amplifier Module
1100	Sensor Card
1200	60 Hz Oscillator Card
1300	Q-II Autolocator Computer Card
1400	Electronics Group Chassis
1500	Meter Rectifier Card
1600	Preassignment LED Card
1700	" " " "
1800	Preassignment Multiplex Card (Piggyback)
1900	Line Amplifier Module
2000	Remote VSO Control
2100	
2200	Remote Shuttle Control
2300	
2400	Remote Electronics Chassis
2500	
2600	Remote Autolocator Control

TABLE 4.1-2. Unit Series Assignments.

4.2 PREVENTIVE MAINTENANCE

4.2.1 CLEANING

4.2.1.1

The heads should be cleaned periodically to avoid excessive build up of contaminants from the tape. This can be done usually with methyl alcohol (methanol) or, in stubborn cases, with methyl-ethyl-ketone (MEK). A swab of cotton or other soft material should be used, to avoid scratching the soft metal of the heads. If MEK is used, keep it off all other surfaces, as it can easily damage plastics and painted surfaces.

4.2.1.2

If other surfaces of the equipment need cleaning, a mild detergent on a damp cloth should be used. Avoid getting fluids into the mechanism; any spillage should be immediately wiped up and cleaned.

The formica surfaces of the cabinet can be cleaned in a similar manner or, in stubbon cases, with alcohol or acetone.

> WARNING: Cleaning with strong solvents such as MEK or acetone should not be done casually or frequently, due to the danger of damage, furthermore, when they are used, adequate ventilation must be provided, for health reasons. Practically all solvents are flammable, and their vapors explosive.

4.2.1.3

Dust should not be allowed to accumulate on the transport, as the very fine dust particles can eventually find their way into the bearings and cause premature wear or binding.

4.2.2 DEMAGNETIZING

4.2.2.1

The record and playback heads should be demagnetized ("degaussed") whenever a fresh reel of tape is to be loaded, or after any substantial period of use (e.g., daily). In addition, all three heads should be demagnetized prior to loading and threading a pre-recorded alignment tape, as insurance against permanently damaging it. Tapes should be removed from the machine, and all tapes kept away from the immediate vicinity, while demagnetizing the heads. Demagnetizing should be performed with the machine turned off.

4.2.2.2

Turn the demagnetizer on while several inches away from the heads, move it slowly to the head gaps, along the row of gaps, and slowly away from the head several inches before turning the demagnetizer off. Each head should be processed in this manner in turn. (It is not necessary to turn off the demagnetizer until the last head has been done.)

> WARNING: Exercise extreme care to avoid scratching or marring the polished surfaces of the heads. It is preferable to use a demagnetizer which does not require actual contact with the head.

4.2.2.3

If the demagnetizer should inadvertently be turned off while close to the heads, it will probably result in the heads becoming strongly magnetized, and the heads must then be properly demagnetized as described above.

4.2.3 LUBRICATION

4.2.3.1

All bearings in the machine are permanently lubricated, and do not require any periodic lubrication. It is particularly important that all oil and grease be kept away from the reel motors. Under no circumstances should any lubricant of any kind be applied to the motor commutator or brushes! The covers should never be removed from the motors, which are factory-serviceable only.

4.3 ALIGNMENT PROCEDURES

4.3.1 GENERAL

4.3.1.1

These alignment procedures are used to adjust the machine performance precisely to desired parameters, assuming that no malfunctions exist. If the response described for each adjustment cannot be obtained, refer to sub-section 4.4, CORRECTIVE MAINTENANCE.

4.3.1.2

There are no mechanical adjustments to make on the 821B. The heads, idler and tape guides are permanently positioned by precise machining, and cannot be moved. The only alignment adjustments to be made are electronic in nature.

4.3.1.3

The record/playback alignment procedure, paragraph 4.3.2, should be performed in the sequence shown, for two reasons:

(1) For total system performance to conform to standards, the playback performance must first respond properly to the standard tape
(2) Bias level adjustments for minimum distortion will affect high frequency equalization

4.3.2 RECORD/PLAYBACK ALIGNMENT PROCEDURE.

4.3.2.1 PLAYBACK LEVEL AND HF EQUALIZATION.

A. Demagnetize heads per paragraph 4.2.2.

B. Turn power on, and clear all channels by pressing NO REC and PLAY assign buttons on sync panel while rotating the channel selector through all channels (one full rotation).

C. Press LOAD, and thread a standard NAB alignment tape for 15 IPS tape speed. Since it is generally desirable to store alignment tapes "tails out", this would involve loading the tape on the takeup reel hub, and threading to the left, then pressing rewind to transfer the tape to the supply reel.

D. Set tape transport speed switches for 15 IPS (SCAN and 30 IPS tallies extinguished), and sync switch off (tally extinguished). Swing out sync panel to reveal line amps, and swing down the door on front of the cabinet to reveal the preamps.

E. Press PLAY, and locate a 1kHz "0" VU reference on the tape.

On the line amps adjust the play level control (see Figure 4-1), on each channel in turn, for "0" reading on the corresponding VU meter.

Figs 4-1 & 4-2 to be inserted here

F. In "play", locate a 10kHz "0" VU reference on the tape. On the preamps are two rows of playback equalization controls (see Figure 4-2), for 15 IPS and 30 IPS respectively. In the upper row (corresponding to the 15 IPS tape speed being used), adjust each control in turn, for a "0" reading on the corresponding VU meter.

> NOTE: If 30 IPS tape speed is to be utilized, then the forgoing procedure (F) should be repeated at 30 IPS, using a 30 IPS standard NAB alignment tape.

G. Press FORWARD and wind the alignment tape to the end, on the takeup reel; press LOAD, and remove the tape and store it.

4.3.2.2 BIAS AND RECORD LEVEL ADJUSTMENTS

A. Thread a blank tape on the transport.

B. Assign all channels to record-ready, by pressing the REC button on the sync panel while rotating the channel selector through all channels (one complete revolution).

C. Apply a 1kHz sine wave signal at +4 dBm level to each input, in turn or simultaneously.

D. Set all rec level controls on the line amps (see Figure 4-1) at approximately mid-rotation.

E. Place the machine in record mode (press REC and PLAY simultaneously).

F. On the preamps (reference Figure 4-2), for each channel in turn, back off the bias level control counterclockwise, then advance it clockwise slowly while watching the VU meter for that channel. Continue turning the control clockwise until the VU meter has reached a maximum reading and dropped back to a 1/4 to 1/2 dB lower reading. Then readjust the rec level control on the line amp for that channel (Figure 4-1) for a "0" reading on the VU meter. Press STOP when all channels have been adjusted.

4.3.2.3 RECORD HF EQUALIZATION.

A. Apply a 10kHz sine wave signal at +4 dBm level to each input, in turn or simultaneously.

B. Place machine in record mode at 15 IPS and, on the preamp for each channel (reference Figure 4-2), adjust the record equalization

simultaneously in practice, and assign this number of channels to REC with the remaining channels assigned to NO REC. Set for either 15 IPS or 30 IPS speed, sync off. Monitor any one of the recording channels, making sure the monitored channel is assigned to "play".

B. With a blank tape threaded and no signal applied, start the tape in record mode (press RECORD and PLAY simultaneously). Turn up the monitor gain sufficiently to hear the tape noise or to read it on a meter, and adjust the noise control on the bias module (Figure 4-3) for minimum noise level. Press STOP.

4.3.4 TAPE SPEED PHASE LOCK ADJUSTMENT.

This adjustment should be made when the machine has been turned off for 1/2 hour or more, as heat resulting from running will affect the meter readings. The VSO switch must be in NORMAL position.

A. Remove the tpim plate surrounding the left hand switch group. Locate the three recessed controls just to the right of the POWER switch (see Figure 4-4).

B. With a tape threaded, put the machine into play at 15 IPS. Observe the meter on the VSO unit. Adjust the 15 IPS control slowly to a position where the meter is steady at a reading of about 10% of full scale. Repeat at 30 IPS with the 30 IPS control, and again at SCAN (60 IPS) with the scan control.

C. Press STOP. Replace trim plate.

> NOTE: As the tape continues to run at any speed, the meter reading will slowly drift upward, which is normal. The maximum meter reading after a long continuous run should not be more than about 90% of full scale. A slight fluctuation of the meter pointer is normal. The pattern of radial lines on the top of the tape idler should appear stationary when viewed under a 60HZ neon (or fluorescent) light.

4.6 THEORY OF OPERATION

4.6.1 GENERAL

4.6.1.1

The theory of operation is presented primarily as an aid to the analysis of any malfunction which might occur. The overall control system is rather complex, and it would be impossible to list all possible faults and their symptoms. However, a thorough understanding of how the system works will help in pinpointing a problem and in establishing its correction.

This section is sub-divided into three parts, covering:

(1) the tape motion control system,
(2) the multiplex system for presetting the record and monitor conditions, and
(3) the recording and reproducing audio electronics.

4.6.1.2

To attempt to trace a signal through the system by means of the individual schematics and wiring diagrams is complicated and time consuming. For this reason, several "system" type schematics have been included in the manual to simplify that process. While these system schematics duplicate the information in the other diagrams, they combine it in such a way that they are useful also for trouble-shooting. However, during actual maintenance or repairs of the equipment, the individual schematics and parts lists should also be consulted to assure your having completely up-to-date parts information.

When using the system schematics (particularly the tape control system), several things should be kept in mind. First, where diodes are shown without type numbers, they are all type 1N100 germanium diodes. These diodes are characterized by a lower forward voltage drop (approx. 0.3 volts) than for silicon diodes. (Incidentally, the maximum temperature that germanium devices can tolerate is substantially lower than for silicon devices, and they must be treated accordingly.) The second thing to remember is that the undesignated transistors are 2N3702 or 2N3704, depending on whether they are PNP or NPN respectively. Third, the TIP 121 and TIP 127 transistors used in several places are Darlington-connected power transistors, with a Beta gain of the order of 1000. Since each one is actually two transistors in series, the forward base-to-emitter voltage drop is about twice that of conventional transistors.

4.6.2 TAPE MOTION CONTROL SYSTEM

The tape motion control system may be visualized in two parts:

(1) the servo system with its speed control for governing the

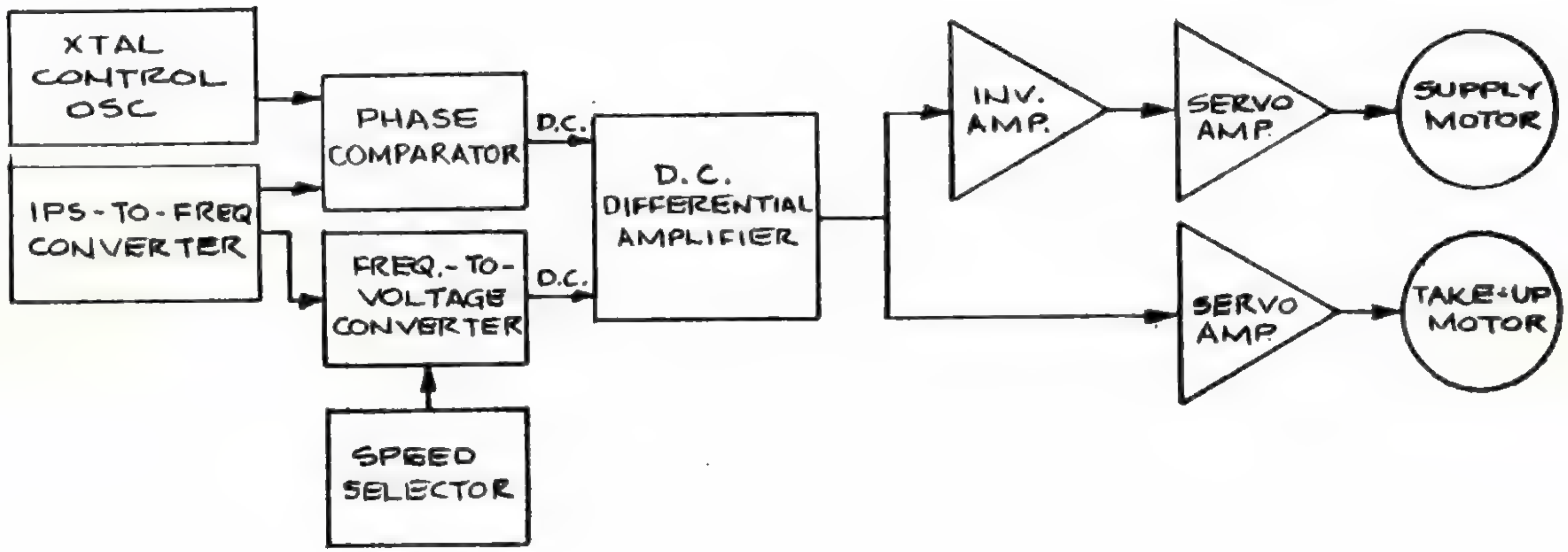


FIGURE 4.6-1. Block Diagram, Tape Speed Control System.

tape motion at recording and reproducing tape speeds of 15 IPS, 30 IPS, and 60 IPS, and
(2) the logic system which inhibits the speed control and substitutes its own signals to the motors for all other tape modes.

With only minor exceptions, these are separate unrelated functions, and can be treated separately here.

An examination of the Tape Control System Schematic, Figure 6-1, shows a "phantom" line separating the upper and lower halves of the diagram. The circuitry below the phantom line is essentially logic type ("on" or "off") circuits, used to determine the mode of tape motion, to start, stop and reverse the tape, and to automatically control the associated switching in the bias oscillator, preamps, line amps and power supply.

These two main functions are relatively independent of each other, as explained later, and the phantom line will help the reader to visualize them separately.

4.6.2.1 SERVO SYSTEM

In this description, we shall first examine the servo system, including the all important phase-lock feature, operating as it would in "play" mode. Figure 4.6-1 is a block diagram of the entire servo system except for the "variable" speed mode.

Tape speed is sensed through the idler located in front of the head stack, around which the tape passes. The idler rotates on bearings having extremely low friction, and tape slippage on the idler is so low as to be virtually unmeasurable. Attached to the idler and rotating with it is a disc having alternate opaque and transparent lines precisely positioned around the disc (as spokes in a wheel). As the idler rotates, these lines "chop" the light traveling from a light source to a photo-transistor, resulting in a series of electrical pulses whose repetition rate (frequency) depends directly on tape speed. (Infra-red light sources and infra-red sensitive photo-transistors are used to avoid interference from outside sources.) There are 480 pulses per second at 15 IPS, or 32 pulses per inch of tape travel.

This transducer, together with pulse-shaping circuits, a frequency doubler and subsequent frequency dividers, constitute the IPS-to-frequency converter in the block diagram. The output frequency at correct tape speeds is always 60 Hz. For comparison with the tape speed pulses, there is a separate oscillator, as shown in the block diagram, crystal controlled for an accurate and very constant 60 Hz signal.

The 60 Hz signals from these two sources are then compared in the phase comparator, whose D.C. output depends on the phase relationship between the two signals. This D.C. voltage is applied to one input of a differential amplifier.

Simultaneously, the doubled frequency (960, 1920, or 3840 Hz, depending on assigned tape speed) is also fed to another converter (frequency-to-voltage converter in the block diagram) whose D.C. output voltage depends on tape speed. This output is fed to the other input of the differential amplifier. The D.C. output of the differential amplifier depends on the difference between these voltages, and is fed to the servo amplifiers driving the two reel motors.

Observe, in the block diagram, the inverting amplifier ahead of one of,the servo amplifiers. This is provided so that as the voltage on one motor is increased to speed it up, the voltage to the other (opposing) motor is reduced, in order to aid the "speed-up" process and to keep tape tension down where it belongs.

This speed control process is described in detail in the following paragraphs. An overall control system schematic, Figure 6-1, located in Section 6.0: DIAGRAMS, should be referred to while following this detailed analysis.

4.6.2.2 IPS/FREQUENCY CONVERTER

In the upper left corner of the schematic (box marked "SENSOR AND PULSE GENERATOR") are shown the LED infra-red light source D1102 and D1103 and the associated infra-red sensitive photo-transistors Q1102 and Q1103. As described above, the rotating disc interrupts and restores the light directed at the photo-transistors, which are precisely positioned so that they are simultaneously excited. (They are also placed across the disc from each other to minimize the effect of any eccentricity of the disc.) The "chopped" light turns the photo-transistors Q1102 and Q1103 on and off, thus intermittently grounding the emitter of Q1104. The resulting approximately-square wave signal on Q1104's collector is further amplified and "squared" by Q1105 acting as a switch.

The third "chopped light" switch (D1101 and Q1101) and associated circuits are described later in paragraph 4.6.2.9: DIRECTION SENSE CIRCUIT.

The next part of this circuit, comprising Q1106, Q1107, and Q1108, is somewhat unconventional. If the disc is not turning, Q1105 will be "on" or "off", depending on where the disc stopped. In either case, capacitors C1102 and C1103 will be charged to their applied voltages, no D.C. current will flow, and Q1106 and Q1108 will be off (non-conducting). With no voltage across R1108, Q1110 is also off, and the voltage at TP1105 is zero (ground potential). The significance of this is explained later.

With the disc turning, charging current will be applied to the capacitors, in first one direction and then the other. Assume for the moment that the disc was stopped in a position to leave Q1105 cut off. The left side of C1102 will be at -18V., and the right side will be at about -3.9V. (The latter is as far negative as it

could go while C1102 was charging, consisting of the forward diode voltage of Q1106 base-to-emitter plus the emitter voltage of -3.2V.) Now, when the disc starts turning, Q1105 suddenly turns "on", clamping the junction of R1106 and R1107 at -3.2V. Charging current immediately flows thru R1107, C1102 and C1103. Most (99%) of the initial voltage change will take place across C1103 until, in a matter of microseconds, the voltage at the right side of C1102 will arrive at about -1.8V. (-3.2V. + the two .7 volt drops across the Q1107 and Q1108 base-to-emitter forward diode voltages). At this point, C1103 can charge no further, and only C1102 is now charging thru R1107. As the disc continues to turn, the switch Q1105 suddenly opens, -18 volts is applied thru R1106 and R1107, and the foregoing process reverses; C1103 re-charges to the -3.9 volt level where it is clamped by Q1106 base-to-emitter again, etc.

During the time that C1103 is charging in either direction (several microseconds), Q1106 and Q1108 are biased "off", as described earlier for the motionless disc. However, during the rest of the time, either Q1106 or Q1108 is conducting, turning Q1110 on thru R1109 and clamping TP1105 at -18V. Thus, during the short C1103 charging time, TP1105 is unclamped and allowed to swing positively to 0 volts, thus forming a positive-going pulse from a -18 volt base line.

Since this phenomenon occurs when Q1105 is clamped and again when it is unclamped, the pulse frequency at TP1105 is twice that of the square wave from the light chopper.

As Q1107 is turned on and off (at the light chopper frequency), the resulting square wave voltage across R1110 is differentiated thru C1104 and R1111 and applied to the base of Q1109. The result is a series of positive-going pulses at chopper frequency, applied to IC1101. The rest of that circuit will be described as part of the logic circuit for stopping tape motion.

The doubled frequency pulses (TP1105) are applied to IC701 (shown in the next box, marked "COUNTER"), which is a frequency divider. Only three of the outputs of IC701 are used: divide-by-16, divide-by-32, and divide-by-64. In operation, only one or two of these are used at a time; the other two (or one) will be inhibited by the "SCAN" and "30 IPS" switches (shown below the COUNTER box in the middle of the schematic), as described below.

When both "SCAN" and "30 IPS" switches are off, the divide-by-32 and divide-by-64 outputs are both inhibited by grounding the output capacitors C703 and C704, and only the divide by 16 goes through. This is a square wave from IC701 at one-sixteenth the input pulse frequency, or 60 Hz for 15 IPS. The positive voltage excursion is differentiated thru C705, R708, and R717 (in the PHASE COMPARATOR box). The negative excursion is differentiated thru C705, R708, and the base-to-emitter current in Q703, turning Q703 on briefly. Note that only the negative-going pulses are effective, the positive pulses serving only to bias Q703 farther "off".

When the "30 IPS" switch is on, the divide-by-32 output is enabled (no longer grounded), and both divide-by-16, and divide-by-32 goes through. When the "30 IPS" switch is off, and the "SCAN" switch is on, the divide-by-64 is enabled and the divide-by-16 is now inhibited. (Note that this last operation is accomplished by applying -24 volts thru R705 to the base of Q712, clamping divide-by-16 to ground.) With divide-by-32 inhibited, only divide-by-64 goes through. When both "SCAN" and "30 IPS" switches are on, only divide-by-16 is inhibited, and both divide-by-32 and divide-by-64 goes through. Table 4.6-1 shows the output combinations enabled for the four switch combinations.

Insert TABLE 4.6-1 (Frequency Divider Inputs) here

When two counter outputs are enabled at the same time, it does not result in confusion at the phase comparator, for the following reason. At the moment when the divide-by-32 voltage is swinging either positive or negative, the divide-by-16 voltage is swinging negative. Thus, when the divide-by-32 swings positive, it cancels the unwanted negative swing of the divide-by-16 output, and no pulse results at the base of Q703. When the divide-by-32 swings negative (where we want a pulse), the divide-by-16 also swings negative, and actually enhances the negative pulse at the Q703 base. The same holds true with the divide-by-64 and divide-by-32 outputs where only the divide-by-64 is desired.

4.6.2.3 PHASE COMPARATOR

The block directly below the COUNTER box on the schematic, entitled "60 Hz XTAL OSC", is shown in detail in its own schematic, Figure 6-13. It consists of a 3.579 megahertz crystal identical to those commonly used in color television receivers, and an IC which provides an oscillator circuit for thh crystal and a frequency divider to "count down" from 3.579 MHz to 60 Hz. Later systems use a 3.93216 megahertz crystal and a different IC, with the same results. The output is essentially a square wave.

The oscillator output is fed thru R720 (box marked PHASE COMPARATOR) to the base of Q706, turning Q706 on and off at a 60 Hz rate. The resulting square wave is differentiated thru C712 and R712. The negative pulse thus formed is applied to the base of Q702, turning it on for about 350 microseconds, and then turning it off until the next pulse which occurs about 16 milliseconds later. When Q702 is "on", C711 is clamped to ground and discharged. During the Q702 "off" period, C711 is charging thru R710 to about -8.5 volts, more or less linearly, at which time the cycle repeats itself. The resulting 60 Hz voltage "ramp" is applied to the D701 cathode.

While all this is happening, the pulses from the frequency divider (COUNTER) are being applied, also at essentially 60 Hz, to Q703, as described above in paragraph 4.6.2.2. Each negative pulse turns Q703 on for about 150 microseconds, clamping its collector to ground. During this period, Q704 is turned on thru R716, clamping

one end of R719 to -18 volts. Simultaneously, C709, which has accumulated a negative charge during the Q703 "off" period, drives R704 in a positive direction sufficiently to draw current thru D701. This, of course, limits the positive voltage excursion of the R704/D701 junction, and this is the voltage applied thru D702 to the base of emitter-follower Q705. (Since the time constant of R704 and C711 is many times as great as the duration of the pulse, no appreciable change in voltage across C711 takes place.)

The voltage across C713 is established by the emitter follower during the pulse "on" time. If the C713 voltage is more negative than that applied by Q705, it is immediately discharged appropriately to a less negative voltage by Q705. On the other hand, if the C713 voltage is too low, Q705 will not even conduct until the capacitor has charged thru R719 and Q704 to the point where Q705 again conducts and limits any further charge. During the "off" period between pulses, both Q704 and Q705 are turned off, and the only discharge path for C713 is thru R2005 and R2004, which is negligible.

It can be seen from the foregoing description that Q703, Q704, and Q705 "sample" the instantaneous voltage across C711 at a time determined by the instantaneous position of the tape, and then "hold" that sample until time to sample it again. This constitutes a classical repetitive "sample-and-hold" application.

If successive pulses from the tape movement are later and later relative to the 60 Hz oscillator pulses, the sampled ramp voltages will be more and more negative, and it will be seen farther on in this description that the result is to bias the servo amplifiers in a direction to speed up the tape. Of course, the opposite is true if the tape motion is too fast.

The voltage divider comprising R2004 (VSO box) and the parallel combination of R729 and R730 (DIFFERENTIAL AMPLIFIER box) reduces the effect of the phase comparator to a small fraction of that of the primary speed control to be described below. In this way, the phase-lock control acts as a sort of "vernier" control over the basic speed control, as is explained in more detail later.

4.6.2.4 FREQUENCY-TO-VOLTAGE CONVERTER

The pulses from the tape speed sensor are also fed to the frequency-to-voltage converter (box directly below PHASE COMPARATOR on schematic) thru R703 anc C715. (During servo operation, -24 volts is applied thru R821 to D703, effectively disconnecting the diode.) These positive-going pulses turn on Q708 very briefly (a few microseconds), long enough to discharge C719. During the "off" period between pulses, C719 is being charged in a positive direction (toward ground potential) thru whichever speed pot and associated resistor has been selected by the "SCAN" and "30 IPS" switches. For example, with the switches "off" as shown on the schematic, 15 IPS is the selected speed, and C719 charges thru R401 and R404. The voltage to which C719 will charge depends (for a

given total "speed pot" resistance, R404 plus variable R401) on the inter-pulse period, and will therefore decrease as the speed increases. Thus, the average voltage across C719 is inversely proportional to tape speed (approx.). The output waveform is a series of "sawtooth" voltage ramps, and therefore consists of a D.C. component and many A.C. harmonics of the pulse frequency. The two stage filter (LOW-PASS FILTER box) which follows the converter effectively eliminates the A.C. components of the signal, and passes only the D.C. voltage level.

A comprehensive analysis of the operation of this active low-pass filter is beyond the scope of this writing, and the interested reader is referred to the many published textbooks on the subject. It is sufficient for our purposes here to consider that the filter output is an essentially pure D.C. output proportional to the average of the sawtooth voltage applied at the filter input.

4.6.2.5 DIFFERENTIAL AMPLIFIER

The main characteristic of a differential amplifier is its response to the voltage difference applied to its two inputs. In the application described here (see DIFFERENTIAL AMPLIFIER box), the two inputs come from the low-pass filter and from the phase comparator thru the VSO, respectively. The latter voltage, applied to Q710, is determined mainly by the voltage divider R729/R730, and is modulated only slightly by the phase comparator; the basic voltage is approximately -13 volts. This holds the emitters of Q710 and Q711 at about -13.5 volts, so that the base of Q711 must be very close to -13 volts in order for Q711 to "capture" its share of the current and become an amplifier. Thus, the tape speed must be such that the frequency-to-voltage converter and low-pass filter produce -13 volts. Too low a voltage will speed up the tape motion and, conversely, too high a voltage will reverse the torque and slow down the tape motion, as will be seen presently. In practice, the speed pot is adjusted so that, as the tape approaches the proper speed, the low-pass filter output will arrive at the proper voltage and allow the phase comparator to assume control.

Referring once more to the phase comparator, in the 1/60 second period between pulses, the capacitor C711 will charge from 0 volts to a little over -8 volts, and this represents the total voltage range out of the phase comparator for controlling the tape speed. After being applied thru the voltage divider formed by R2004 and the paralleled R729 and R730, the maximum voltage change available at the base of Q710 is little more than .2 volts, which corresponds to a tape speed change of about 14.75 to 15.25 IPS, when set for 15 IPS. Thus, the phase comparator provides a vernier control of tape speed.

The differential amplifier output is taken from the collector of Q711, which is connected to the bases of the servo amplifier transistors Q802 and Q807. The current thru the Q711 collector will increase if the low-pass filter output voltage goes less negative (tape speed decreases), or if the phaae comparator output

voltage goes more negative (tape phase pulse is late relative to the xtal osc. pulse).

4.6.2.6 SERVO AMPLIFIERS

Transistors Q802 and Q302 constitute the "servo" (or driver) amplifier for the take-up reel motor. Similarly, Q808 and Q301 constitute the supply reel motor servo amplifier, in this case preceded by an inverting amplifier (Q807) designed to provide some negative feedback.

To understand the operation of the servo amplifiers, look first at the take-up reel motor amplifier, Q802/Q302. The motor has approx. -19 volts applied to one terminal, while the other terminal goes thru Q302 and R303 to ground. Q302 acts as an "emitter follower", so that it applies to the motor winding whatever voltage is on its base. As long as Q802 is biased "off", R808 holds Q302's base at emitter potential, Q302 is "off", and no current flows thru the motor. However, as the base of Q802 goes negative by about 1.5 volts (Q802 is a Darlington-pair, and has a double diode forward voltage drop) and biases Q802 "on", the collector of Q802 swings positive (less negative), swinging the base of Q302 positive with it. The Q302 emitter "follows" its base in a positive direction, applying a voltage drop across the motor which starts the tape moving. The amount of voltage so applied (and therefore torque) is proportional to the Q802 base current, supplied by the differential amplifier output.

Observe R809 connected between the Q802 base and the tape lifter solenoid B303. During servo operation, the tape lifter is not energized and, since its coil has only a few ohms resistaace, R809 is virtually grounded. This being true, the first 3/4 milliampere of current from the differential amplifier is used to produce the fraction of a volt across R809 to forward-bias Q802, and all further increase in base current is amplified to produce torque. as explained above.

The operation of the supply motor servo amplifier is essentially the same; however, it is not driven directly from the differential amplifier, but by the inverting amplifier instead. This will be explained later.

With the tape at rest or moving very slowly (such as right after PLAY is started), the filter output voltage is only slightly negative, applying that low voltage to the base of Q711 thru R728. This forward-biases Q711 strongly, and effectivey clamps its emitter to the base of Q802. The combined forward diode drops across D302 and Q802 will permit the base of Q802 to go only about 3 volts negative, so the rest of the voltage drop (about 15 volts) appears across R731 in the differential amplifier. This same -15 volts is on the emitter of Q710, biasing it "off", and the phase comparator is momentarily out of the circuit. The Q802 base current turns Q802 on, and essentially full voltage is applied to the take-up motor.

If the tape "overshoots" its required speed, the filter output goes to more than the desired -13 volts. With Q710's base held at -13 volts, the emitters of Q710 and Q711 are held at about -13.5 volts, Q711 is now biased "off", Q802 loses its source of base current, and torque is applied to the supply motor to slow down the tape, as described next.

It was explained earlier that the exciting current for the takeup servo amplifier (at the base of Q802) came from the differential amplifier. The corresponding exciting current for the supply reel servo amplifier, applied to the base of Q808, comes thru R818 and R819 from Q810 (below the phantom line). During play and record modes of operation, Q810 is clamped "on", and its collector is held at -24 volts. The resulting current would turn on the supply servo amplifier and apply full reverse torque, if it were not inhibited by Q807.

The transistor Q807 constitutes a sort of differential amplifier by itself, the two inputs being its base and its emitter, respectively. A negative voltage increase on its base would increase its collector current, while a negative voltage increase on its emitter would decrease the collector current. As the Q807 collector current is increased, its voltage swings positive (less negative), so that less voltage is applied to R818, resulting in less base current at Q808 and therefore less reverse torque.

The differential amplifier output which is connected to the base of Q802 is also connected to the base of Q807. Thus, a negative voltage increase resulting in a takeup motor speed-up would simultaneously result in a decrease in reverse torque at the supply reel motor.

The reel drive motors are brush-and-commutator type motors with permanent magnet fields. A significant characteristic of such a motor is its action as a generator. When the shaft of a permanent magnet motor turns, the motor generates a D.C. voltage proportional to its speed, of the same polarity as the voltage applied to the motor to drive it in that direction. (This generated voltage is called back emf.) Because of this, the motor draws less current, for a given applied voltage, as it picks up speed. Conversely, if the motor shaft is forced to turn in the opposite direction, the back emf is of the opposite polarity and the current increases; so does the torque.

As the takeup reel fills up with tape and the radius of the tape pack increases, it takes more motor current to pull the tape through. Part of this current increase results from the reduced motor speed, and the rest of the increase requires more takeup servo amplifier drive. At the same time, the supply reel is unloading and reducing its tape pack radius, speeding up that motor and increasing its back emf. In order to maintain uniform tape tension and motion throughout a reel of tape, the relationships between servo amplifier gains, thresholds and other characteristics are quite complicated, and far beyond the scope of this writing. It

is sufficient to say that any indiscriminate changing of the values or tolerances of resistors or other components of the servo system can only result in degrading its performance.

The network consisting of R701, C701, C725, D704 and D705 constitutes a negative feedback lead-network to slow down the high frequency response of the servo system and stabilize its operation.

When the play function is not in operation, Q810 is off, and ground potential is applied thru R826, R821 and D703 to the base of Q708 in the freq.-to-voltage converter, saturating Q708 and holding its collector at -18 volts. This biases off Q711 in the differential amplifier turning off Q802 and Q807. The base of Q808 is no longer biased on (thru R818 and R819), and thus both servo amplifiers are turned off.

4.6.2.7 CONTROL LOGIC SYSTEM

The portion of the control system described below, the "logic" system, involves on-off function only (in contrast with the "analog" servo system described above), and serves to establish the necessary conditions for each operational mode. Referring again to Figure 6-1, the entire tape motion control logic system is shown schematically below the phantom line (except for the stop mode tape tension circuit at the top).

The various modes are initiated by the six switches shown at the left end of the diagram: STOP, PLAY, REC, LOAD, FWD, and REW. Each switch has associated with it a thyristor and a tally light. The thyristor acts electronically as a "latch" to hold the circuit engaged once the switch has been actuated and then released. For purposes of this description, the important characteristics of the thyristors used in the system are as follows:

(1) When the thyristor is "off", it will remain off as long as the "gate" electrode is held at cathode potential.
(2) With voltage applied in the correct polarity across the thyristor (anode to cathode), swinging the gate at least .8 volts positive with respect to the cathode for a few microseconds will "trigger" the thyristor into conduction, and it will remain in this state even though the gate swings back to cathode potential.
(3) Once conduction is initiated, it can be interrupted only by reducing the current thru the thyristor to zero, or at least below the holding current (usually a few milliamperes). This can be done by forcing the voltage across the thyristor to zero or less, or by forcing the gate negative.
(4) In conduction, the forward voltage drop across the thyristor, at the currents encountered in this system, is about 1 volt.

With these things in mind, we can proceed to the switch circuits,

all of which work essentially alike. Starting with the "STOP" switch, we see that the thyristor Q505 acts as a switch, in series with the lamp I503 as a load, between +1.2 volts and -24 volts. (The reason for the +1.2 volt common, rather than ground, will be explained later.) The gate of Q505 is held at cathode potential thru R501, and no current flows. If we now actuate the "STOP" switch, the +1.2 volts is applied thru R502 to the gate, turning Q505 on. The cathode swings to within about a volt of the anode, and the lamp has about 24.2 volts across it, drawing 40 milliamperes. This state is maintained when the switch is released. Note that the common circuit to all the rest of the switches goes thru the stop switch normally-closed contacts, so that voltage is removed from the other switches whenever "STOP" is actuated. This provides a double assurance of turning off whichever thyristor was previously turned on, as well as preventing any simultaneous operations.

Basically, all of the switches turn on their thyristors in the same manner. There are, however, some interlock circuits associated with them, which are explained later.

As noted earlier, once a thyristor is turned on, it remains on as long as it is carrying current, as if it were a diode. To turn it off, we must interrupt that current, which means reducing to zero, or reversing, the voltage across the thyristor momentarily. With one exception (explained later), this is done thru the commutating capacitors C501 thru C504. These are all connected to one line (LOAD), and a sharp positive voltage pulse applied to any one of them will be coupled thru all of them. Thus, whenever any thyristor is turned on (except RECORD), the sudden positive excursion of its cathode is coupled to the other cathodes. If one of the other thyristors is one, the positive D.C. charge on its capacitor plus the positive pulse will drive its cathode positive with respect to its anode, thus reverse-biasing it and reducing its current to zero, and turning it off; it takes less than a millisecond for this to happen.

The interlocks mentioned earlier are provided to prevent simultaneous operation of switching circuits, where such operation would result in malfunction. Note than when "FWD" is pressed, its normally closed contacts are open and prevent "REW" from actuating. The same thing is true in reverse. Thus, it is impossible to actuate "FWD" and "REW" simultaneously. Similarly, when "LOAD" is pressed, neither "FWD" now "REW" will go on. The "STOP" interlock was explained above. On the other hand, "LOAD" and "PLAY" can be actuated simulaneously, as there is no interlock between them.

A different type of interlock is used for the "REC" switch. When "PLAY" is not engaged, the anode of Q504 is at -24 volts, so that there is no voltage across Q504 with which to turn it on. When "PLAY" is engaged, the Q504 anode is at about +.2 volts and it is ready to be turned on. If the "PLAY" button is released, pressing the "REC" button cannot turn Q504 on since D501 is reverse biased and will not supply the necessary gate current to Q504. However, if "PLAY" is held down, gate current is supplied thru R504, and now

both Q504 and Q506 are on. Pressing any one of the other switches will, as explained earlier, turn off "PLAY" thru one or two of the commutating capacitors, and when "play" is off, "rec" goes off with it.

When both "play" and "rec" are on, C505 charges thru R507 to the voltage across I502, about 23 volts. If "PLAY" is then pressed, the negative end of C505 is swung in a positive direction thru R504, putting a positive pulse on the cathode of Q504, reducing the Q504 current to zero and turning it off. Or, alternatively, pressing "REC" puts a strong negative pulse on the Q504 gate, which will turn Q504 off as stated earlier.

Each switch circuit, when it goes on, swings its associated lamp voltage to about +.2 volts, and that same voltage swing is applied to the external circuit controlled by that switch. Some of the control circuits (load, forward, and rewind) involve inhibiting of transistors by forcing their bases to ground potential thru diodes. Since the sum of the thyristor and diode forward voltage drop is greater than the forward bias of a transistor, it is necessary to hold the thyristor anodes sufficiently positive to make sure the transistors will be "off" when inhibited, hence the +1.2 volt common. This voltage is obtained by connecting the motor power supply positive terminal to ground thru the double diode D303. The current thru the power supply also passes thru D303, holding its anodes at about +1.2 volts.

4.6.2.8 PLAY CONTROL CIRCUITS

On the system schematic (Figure 6-1), refer to the area just below the phantom line in the right hand half of the diagram. The play control from the switch, labeled "PLAY", goes thru R823 and R824 to the base of Q810. Before "play" is activated, this line is at -24 volts, and Q810 is biased off. When "play" is activated, this line applies a forward bias to Q810, turning it on. The collector swings to within about .2 volts of -24 volts, with the following results.

(1) Thru D809, Q803 is prevented from being turned on by Q801 (to be explained later).
(2) The supply servo system has -24 volts applied to it thru R819.
(3) Diode D703 in the freq-to-voltage converter is reverse biased, allowing the converter to work as described earlier.
(4) Forward bias is removed from the base of Q809, turning off "PRE" (unless the "PRE" switch is on or "REC" is activated).
(5) Thru D310, -24 volts is applied to the winding of relay K301, enabling it to operate when the record switch is turned on (explained in detail later).

The tape is now moving under control of the servo system described earlier. The tape lifter drive transistor is off, and the tape lifter solenoid is de-energized. Although there is now a negative

voltage on the "MOTION" line (as explained in the first part of paragraph 4.6.2.2), Q801 is inhibited by D803 and the very low resistance of the tape lifter solenoid to ground. Similarly, there is a negative voltage on the "DIR Q" line (explained below), but Q805 cannot get any current from Q806 which has no forward bias and is turned off. Thus, none of the servo amplifier inhibitor circuits below the phantom line are in effect.

4.6.2.9 DIRECTION SENSE CIRCUIT

To understand the derivation of the direction signals (e.g. "DIR Q"), it is necessary to refer to the SENSOR AND PULSE GENERATOR block of the diagram. The integrated circuit IC1101 is a digital dual "D" type flip-flop circuit, of which only one is in use here. It is characteristic of this device that when a positive-going pulse (trigger) is applied to the "clock" input (pin 11 of the IC), the "Q" output (pin 13) will assume the voltage state which was present at the "data" input (pin 9) when the pulse occurred, and will hold that state until the next pulse. The voltage state of the "Q" output (pin 12) is always opposite that of "Q".

The voltage on pin 9 is determined by the current thru Q1111, which in turn depends on the amount of light striking photo transistor Q1101. This last item, together with its light source D1101, is the third "chopped light" switch mentioned in paragraph 4.6.2.2: IPS/FREQUENCY CONVERTER. When light to Q1101 is interrupted, pin 9 swings negative (from ground potential). When light to Q1102 and Q1103 is interrupted, a pulse is applied to pin 11. Thus, for forward tape motion, we want Q1101 to be dark at the moment the pulse appears, so that the "Q" output will be negative. (The fact that pin 9 swings positive and then negative again between pulses does not alter the negative voltage on pin 13, as stated above.) To accomplish this, the D1101/Q1101 light switch is very accurately located so that a line on the chopper disc will encounter it 1/4 cycle (of chopper frequency) ahead of the other light switches, for forward tape motion. This angular displacement amounts to less than 1/2 degree, with a tolerance in the order of 5/100 degree. This placement is done precisely and permanently in manufacture, and should never be tampered with.

When the disc is turned in the opposite direction (reverse tape motion), the pulse occurs when pin 9 is positive, and consequently pin 12 is negative.

4.6.2.10 STOP CONTROL CIRCUIT

Assuming the machine to be running in "PLAY" mode, let us now push the "STOP" button. The cathode of Q505 swings positive and is latched at about +.2 volts. The positive voltage on the "PLAY" line is abruptly removed, by commutation thru C503 and C504, and by interruption of the common return; the "PLAY" line swings to -24 volts. Q810 is turned off, and its collector swings positive to ground potential thru R826. Excitation voltage to the supply servo

amplifier (thru R819) is removed. Current thru R821 and D703 in the Frequency-to-Voltage Converter saturates Q708, removing excitation voltage from the takeup servo amplifier.

The positive swing of the Q810 collector is coupled thru C802 and R806 to the base of Q803, pulling its collector to -24 volts. The inhibiting diode D803 is now reverse biased, allowing Q801 to be driven to saturation by the negative voltage from the "motion" line. (The source of this voltage is explained in the first three paragraphs of 4.6.2.2).

The negative voltage now sustained on the collector of Q803 does four more things:

(1) The tape lifter solenoid is energized, lifting the tape from the heads.
(2) The -24 volts is applied thru J301 pin 29 to the power supply, increasing the voltage on the motors to about -33 volts.
(3) Negative voltage is applied thru R811 to the base of Q806 saturating it and clamping the emitters of Q804 and Q805 virtually to ground. With a negative voltage on the "DIR Q" line, Q805 is now clamped "on", which holds the base of Q802 near ground and thus disables the takeup servo amplifier.
(4) The negative voltage is applied thru R809 and R810 to the two servo amplifiers. The supply servo amplifier (Q808) is turned on in full, while the takeup servo is inhibited as just described.

The high reverse torque on the supply reel rapidly slows down the tape motion to a stop, and would actually reverse the tape motion, except for one thing. As soon as the tape motion stops, the voltage on the "MOTION" line drops to zero (ground potential), removing excitation to Q801 and de-energizing the tape lifter circuit. This removes the voltage from R809 and R810, again disabling both servo amplifiers; the tape remains stopped. The removal of tape lifter voltage allows the power supply to revert to the lower voltage of about -19 volts.

When the stop thyristor Q505 latched, it applied +.2 volts thru the "STOP" line and R105 to the base of Q104 (upper right hand corner of the diagram). As an emitter follower, Q104 applies ground potential thru R104 and diodes D304 and D305 to the reel motors. The resulting low and equal motor currents hold a light tension on the tape in the stopped mode.

In stopping from "REWIND" with the tape moving in the opposite direction, the action is identical in all respects but one; now it is the "DIR Q" line that has a negative voltage on it instead, clamping Q804 instead of Q805, and also it is the supply servo amplifier which is inhibited, and the takeup reel motor produces high torque to stop the tape motion.

4.6.2.11 LOAD CONTROL CIRCUIT

Pressing the "LOAD" button latches Q502 on, and commutates all other thyristors off. With +.2 volts now on the "LOAD" line, D802 inhibits the tape lifter circuit, so that "MOTION" line voltage produced when moving the tape will not initiate the stop sequence just described. Turning off Q505 removes the tape tension produced by Q104, and the tape is free to be moved by hand.

If the "PLAY" button is pushed, the load circuit will be commutated off, but if the "LOAD" button is held depressed while pushing the "PLAY" button, both circuits will be latched on simultaneously. The servo system will be turned on up to the servo amplifiers themselves; however, the positive voltage on the "LOAD" line is applied thru D806 and D807 to the two servo amplifiers, holding them off. The only difference observed when moving the tape in these two modes ("LOAD" only or "LOAD/PLAY") is that, in "LOAD" only mode, the preassigned monitor circuits are in effect; with "PLAY" also turned on, the preassignments are cancelled (unless the "PRE" switch is on).

With both "LOAD" and "PLAY" thyristors latched, pressing either button will not change anything, since there is no commutating voltage step available to turn anything off. Thus, when in "LOAD/PLAY" mode, it is only necessary to press "PLAY" and "RECORD" to go into record mode without starting the tape moving. On the other hand, pressing any other button will commutate both "LOAD" and "PLAY" off.

4.6.2.12 FORWARD AND REWIND CONTROL CIRCUITS

The "FWD" and "REW" circuits function essentially identically, the only difference being which servo amplifier is inhibited, as explained below. Hence, a description of the "FWD" mode leads to an understanding of the "REW" mode. Note that the two cannot be engaged simultaneously, as the two switches are mutually exclusive thru their normally-closed contacts.

When "FWD" is pressed, its thyristor Q503 is latched and any other switch circuit is commutated off. With +.2 volts now on the "FWD" line, three things happen:

(1) The supply servo amplifier is inhibited thru D808.
(2) Q806 is inhibited thru D805, disabling the "direction" circuits which would otherwise try to stop the tape motion.
(3) Q803 is turned on thru R807, energizing the tape lifter, raising the motor voltage to -33 volts, and turning on the takeup servo amplifier thru R809 (as described in 4.6.2.10 for "STOP"). The stopped-tape tension is not present since "STOP" is off, and the tape moves toward the takeup reel at full speed.

When "REWIND" is pressed instead, the only differences are that

Q806 is inhibited by D801 instead of D805, Q803 is turned on thru R803 instead of R807, and D804 inhibits the takeup servo amplifier instead of D808 inhibiting the supply servo amplifier.

When "FORWARD" or "REWIND" is dropped out by pushing "STOP" or "PLAY", the tape lifter is held on by the "MOTION" line as long as the tape is still moving in the normal stop mode described above. Q806 is no longer inhibited, and the tape is brought to a complete stop. If "PLAY" was pressed, Q810 is inhibited thru D811 until the tape stops and the tape lifter is released, at which time D811 is "disconnected" and Q810 is allowed to function as described in 4.6.2.8 above.

4.6.2.13 RECORD CONTROL CIRCUIT

As was noted earlier, when the "PLAY" circuit is engaged, -24 volts is applied thru D310 to one end of the K301 relay coil. Up to now, all three relays have remained de-energized, as shown in the diagram. If "PLAY" is held depressed and "REC" is pushed, turning Q504 on, the other end of the K301 coil swings positive and the relay actuates. The K301 contact 8 opening removes -24 volts from S404, the sync switch, to prevent energizing of the sync bus during record mode. The closure of K301 contacts 9/10 energizes K302. It also, thru D307:

(1) Energizes the record bus in the line amplifiers (to be described later);
(2) Thru D401, turns on I404, the "SYNC" tally light;
(3) Thru D306, energizes the "PRE" bus (to be described later), which was released when "PLAY" went on.

K302 now actuates, with the following results:

(1) K303 is actuated, which will hold off the sync bus voltage until K302 releases;
(2) Applies, thru D308, a holding voltage to the record bus;
(3) Completes, thru K301 contacts 6/7, the bias oscillator turn-on circuit.

Upon turning off the record mode, either by releasing "REC" while still in "PLAY" or by pressing another button, K301 immediately releases, opening the bias oscillator turn-on circuit, as well as removing voltage from the K302 coil. The bias output is not interrupted abruptly; rather, it "ramps down" over a period of a fraction of a second, to avoid the clicks and pops on the tape commonly encountered when bias is suddenly interrupted.

The release of K302 is delayed briefly by C303, so that the record bus and sync bus are held in the recording status until the bias level has "ramped" down, after which time K302 and K303 release, and the record, sync and pre buses are restored to the non-recording status.

When the record mode is turned off by pressing "STOP" or fast

shuttle in either direction, the tape lifter immediately lifts the tape, but does so slowly enough that the lifting action constitutes a form of "ramping" down the bias, even though it happens before the bias oscillator is completely off.

4.6.2.14 POWER SUPPLY CONTROL CIRCUITS

Refer to Figure 6-5, Schematic Diagram, Power Supply. The power supply contains two separate DC. power sources, each consisting of transformer, bridge rectifier and filter, and, when the autolocator is supplied, a separate commercial regulated power supply. Each is individually fused, and all of them are turned on by a single switch located on the tape transport.

The secondary voltage of T101 is approximately 40 volts RMS producing, thru the bridge rectifier D101 and filtered by C101, about 60 volts DC. This unregulated voltage is transmitted to the bias oscillator module, where it is regulated and distributed to the various parts of the audio system. This is further described in section 4.6.4.

The secondary voltage of T102 is approximately 27 volts RMS which, after being rectified by the bridge rectifier D102 and filtered by C102, produces about -38 volts DC. This unregulated voltage supplies the 24 volt regulator, and also the reel motor power when in fast shuttle and while stopping. From the T102 secondary center tap we get half-voltage, or about -19 volts DC, filtered by C103, which supplies reel motor power in play mode and when stopped.

The plug-in regulator card in the power supply serves to regulate the -24 volts used for the logic system, and also contains switching circuits and an overload current limiter circuit for the reel motors, as described below.

The -24 volt regulator consists basically of a voltage reference zener diode D206, an amplifier Q202, and transistors Q201 and Q101 connected as a Darlington pair to control the output current. With the card connector pin 1 (J101) at -38 volts, the collector of Q201 is at -38 volts, which is also applied thru R201 and R202 to the base of Q202. With Q201 and Q101 both acting as emitter followers, the emitter of Q101 would also be at -38 volts except for the Q202 circuit. The emitter of Q202 is effectively held at -24 volts by D206. The emitter of Q101 is connected thru pin 10 and R203 to the base of Q202 and, as soon as this voltage rises to about -24.6 volts, Q202 draws base current. The Q202 collector now draws current thru R201 and swings positive to about -24.2 volts. This reduces the voltage on the base of Q201, and the final voltage on pin 10 is slightly over -25 volts.

It should be noted (and remembered) that the ground symbol in Figure 6-5 represents only a common circuit for that diagram, and is not actually at system ground potential. By referring once more to Figure 6-1, in the lower left hand corner, the positive terminal of the reel motor power supply is carried thru J301 pins 25/26 and

D303 to system ground. Thus, the apparent ground shown in Figure 6-5 is actually about 1.2 volts positive with respect to system ground, since all of the reel motor current returns to the power supply thru D303. (The tally light current from all of the static group switches also goes thru D303.)

The case and chassis of the power supply unit are not grounded, but are completely isolated.

On pin 3, the voltage applied from the logic system depends on the status of the tape lifter circuit, as explained in 4.6.2.10: STOP CONTROL CIRCUIT. In play mode or with the tape at rest, pin 3 is at -1.2 volts (relative to power supply common), and with -19 volts on the emitter of Q204, it is biased off. This leaves Q203 and Q102 also "off", and current from the -38 source does not flow to the output. Instead, the collector of pass transistor Q103 is supplied with -19 volts thru D201. With the base of Q205 heavily forward-biased thru R206 from the -38 volt source, both Q205 and Q103 are saturated, and -19 volts is now fed, thru D201, Q103, R103 and M101, to the reel motors.

As more current is drawn from the power supply, thru the total resistance of R103, M101, and the two wires to J301 pins 21 and 22, the voltage drop across this total resistance increases, and the voltage at J101 pin 8 becomes more positive relative to the base of Q205. As soon as this voltage is high enough to exceed the forward drop across D202 thru D205, any further voltage increase (due to increased output current) will force the base of Q205 in a positive direction, reducing the voltage on the base of Q103 and therefore the output voltage. This constitutes a current limiting function, and limits the output current to about 10 amperes. Note that the resistance of the wires is part of this critical total resistance, and must not be changed.

Returning to J101 pin 3, the voltage from the tape lifter circuit, when stopping or in fast shuttle mode, is -24 volts. This drives Q204 into saturation (thru R204 and R205), clamping its collector to -19 volts which, in turn, thru R207 drives Q203 and Q102 into saturation. This now connects -38 volts to the Q103 collector, disconnecting the collector from -11 volts by reverse biasing D201. The current limiting circuit still works as described above.

With the higher voltage applied to the reel motor, and with the associated servo amplifier full on, a considerable amount of current is drawn from the transformer/rectifier/filter combination where, due to its internal impedance, the source voltage drops to about 33 volts.

For the computer power supply (when used), the reader is referred to the power supply manufacturer's data.

4.6.3 PREASSIGNMENT CONTROL SYSTEM

The assignments of channels to be recorded, and of monitor sources to be heard during recording or playback, are normally made in advance of the actual recording or playback process; hence, the term "preassign" (or preset). Since these four separate preassignments can be made not only locally, but also thru a remote control unit, individual direct control circuits would involve a huge number of switches and wires, using up much space and generating a lot of potential maintenance problems. This situation is largely avoided thru the use of a "multiplex" system, described in detail below.

A multiplex system is one in which several independent sources share a single circuit or wire, wherein each source is connected to the circuit only briefly, followed by the next source, etc. The resulting voltages at the other end of the circuit are then "sampled" in synchronism with the transmitted pulses and individually sustained between pulses for each signal, thus producing a continuous signal at the receiving end for each source. The system described here is a composite of individual switch-selected circuits combined with a modified multiplex system, using logic flip-flop (bistable latch) circuits as sustaining memories which not only establish the operating conditions, but also feed back the tally data.

For this portion of the circuit description, the reader is referred to Figure 6-2, Schematic Diagram, Multiplex System. Here, except for the actual audio switching circuits, the complete multiplex system is shown thru one typical audio channel. The diagram is divided into four major portions:

(1) the multiplexer card,
(2) the assignment switches,
(3) one channel of a line amp module, and
(4) part of the LED tally card.

The basic multiplex timing pulses are generated on the multiplexer card.

4.6.3.1 POWER DISTRIBUTION AND VOLTAGE REGULATOR.

In the upper left corner of the diagram, in the Multiplexer Card box, is shown the power distribution system and a switching type voltage regulator. Power from the -24 volt source is filtered thru R1801/R1802 and C1801, and supplied to IC1801 and IC1802, described later. An additional filter R1803/R1804 with C1802 supplies power to the remainder of the system, including the voltage regulator. The important functions of these filters are to prevent the current pulses generated in the multiplex card from feeding back into the -24 volt source, and to present low impedance power sources for the pulse generating circuits themselves.

At start-up, the regulator has no pulsed excitation applied, and

draws negligible current. However, the oscillator (IC1801) immediately starts, and thru pin 7 feeds 25 kHz square wave pulses thru C1808 to the base of Q1807. The resulting positive-going voltage pulses on the collector of Q1807, thru R1811, biases the pass transistors Q1801 thru Q1804 "on" in pulses. These current pulses are in turn fed thru L1801 to C1804, C1805, and the LED card. During the periods between pulses, when the pass transistors are "off", the current from the collapsing field of L1801 is carried thru D1802, so that the current thru L1801 is sustained.

As soon as sufficient voltage has built up on C1805 to exceed the zener voltage of D1801 and the forward base-to-emitter drop of Q1806, that transistor's collector starts to draw current thru C1808, discharging it rapidly and effectively shortening the pulses applied to the pass transistors. This reduces the average power applied to L1801, and holds its output voltage at the appropriate value.

Since the pass transistors are either "on" or "off" during the switching cycle, and spend almost no time in the transition state where there is current and voltage drop simultaneously, they dissipate very little power themselves, which is why switching regulators are so efficient.

If excessive current should be drawn thru the regulator, such as at start-up or from a short circuit or overload, the additional voltage drop across R1801 thru R1804 will bias Q1805 on, applying bias to Q1806 and reducing pass transistor excitation as described above.

4.6.3.2 BASIC TIMING PULSES

The oscillator/counter, IC1801, does two jobs:

(1) It supplies the 25 kHz pulses to the switching regulator described above, and
(2) It supplies binary-coded pulses to IC1802.

The frequency is determined by the R1812/R1813/C1809 network, and all outputs are square wave pulses at their respective frequencies. The voltage swing of each output is between ground potential (logic "1"), and about -10 volts (logic "0").

Although IC1801 actually contains a 14-stage counter (divide-by-2, divide-by-4, divide-by-8, etc.), only three of the outputs are used: divide-by-16 at pin 7 drives the voltage regulator, while divide-by-4096 and divide-by-8192 at pins 1 and 2 are used to drive IC1802. The oscillator portion of IC1801 is running at approximately 400 kHz which, when divided-by-16, becomes 25 kHz (pin 7). The frequency at pin 2, 400 kHz divided-by-8192, establishes the multiplex full-cycle frequency of 48.8 Hz. Actual frequencies are not exactly as stated due to component value tolerances, but neither do they need to be exact.

IC1802 is a dual "binary to one of four" decoder. Each decoder has four outputs, one of which swings negative at a time; which one swings negative depends on what binary code is applied to its two inputs. In our application here, we use both decoders simultaneously by feeding their inputs in parallel, in order to drive separate circuits synchronously.

Figure 4.6-2, Multiplex Timing Diagram, shows the time relationships between the various multiplex signals. Note that one complete cycle (20.4 milliseconds) is divided into four equal time periods of 5.1mS each, designated as phases: Ø0, Ø1, Ø2, and Ø3.

While using this diagram, bear in mind that the uppermost excursion (logic 1) of each line is zero volts (ground potential), and the lower excursion (logic 0) is as shown on the diagram.

When both pins 1 and 2 of IC1801 are at logic 0, pin 4 of IC1802 is at logic 0 and the other 3 outputs are at 0 volts, as shown for Ø0. When IC1801 pin 1 swings positive, IC1802 pin 4 swings positive and pin 5 swings negative for Ø2, etc. It can be seen from the diagram that only one of the four IC1802 outputs (pins 4 thru 7) is negative at any time.

Referring again to Figure 6-2, observe that IC1802 outputs Ø1 thru Ø3 are fed to three switching circuits respectively. Each circuit consists basically of two switches, one of which clamps its output (collector) to 0 volts (e.g., Q1808 during Ø1), while the other (Q1809) clamps its output to -24 volts. This state prevails only during that phase time period. During the other three time periods, both switches are unclamped and their collectors are free to swing to any voltage without drawing current; in other words, they are disconnected. These conditions are indicated in Figure 4.6-2, for the P1406 pins, by heavy lines representing clamped states, and lighter lines to represent the disconnected states. (The Ø0 output circuit involving only the diode D1803 will be explained later.)

4.6.3.3 FLIP-FLOP CIRCUIT.

An essential part of the multiplex system is the bistable latch, commonly called a "flip-flop" circuit. It performs essentially as a switch with a memory, and can be actuated to one or the other of two states. With its power terminals connected to ground and -24 volts (as it is in the application described here), its output terminal will be at either ground potential or -24 volts, depending on which state it was "set" at thru its input terminal. It will remain in that state with the input disconnected, until an appropriate input is applied to change (or "reset") that state. There are three flip-flops in each line amp circuit, (four such circuits per line amp module):

(1) one to control the recording status (FF1),
(2) one to select "playback" or "source" (FF2),
(3) and one for "mute" (FF3).

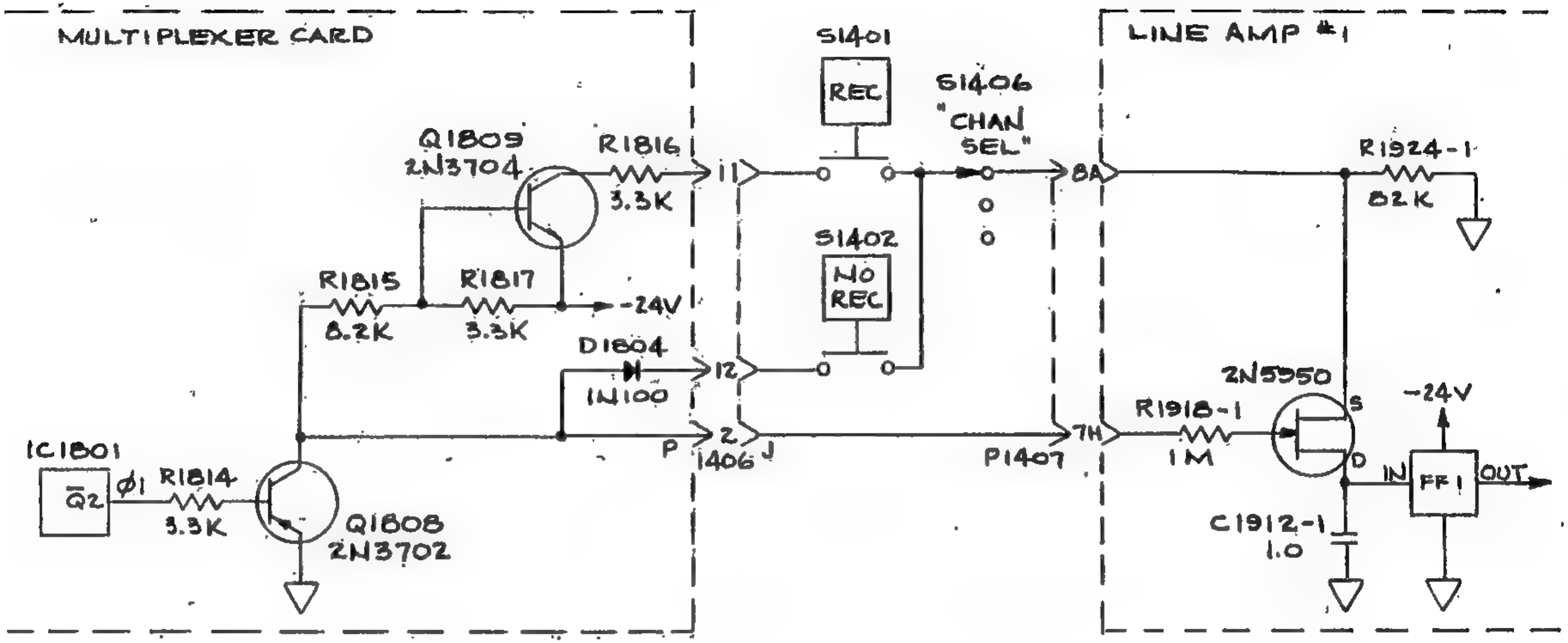


FIGURE 4.6-3. Flip-flop Set/Reset Circuit.

These are special devices of proprietary design, with the three latches permanently encapsulated in a single non-repairable plug-in "triple latch" component, designated as IC1901.

This flip-flop is designed with an unusual feature, as follows. It has only one input (to set and reset the flip-flop), and only one output. The input acts like a second output of the same polarity, but with a substantial internal impedance. If the input is "forced" from one state to the other state (against that internal impedance), the flip-flop will then actuate itself to that other state (e.g., from 0 volts to -24 volts), and will remain in that state until the input is forced back to the first state (i.e., back to 0 volts). The actual voltage appearing on the input terminal (open circuit voltage) is essentially zero volts when the output is at 0 volts (logic 1), but is approximately -15 volts when the output is at -24 volts (logic 0). The purpose of this "input-follow-output" feature will be explained later in 4.6.3.5: TALLY CIRCUIT.

4.6.3.4 ASSIGNMENT SWITCHING.

Referring again to Figure 6-2, in the line amp block, observe a number of 2N5950 field effect transistors (FETs). These are N channel J FETs, and are used as "coincidence" switches, for the purpose of setting or resetting their associated flip-flops.

If you apply a voltage momentarily to several switch inputs in parallel, but turn on only one switch during that moment, there will be only the one output. Thus, the switch turn-on "coincides" with the desired input voltage. By properly timing the individual switch turn-ons to "coincide" with the appropriate momentary input voltages, you have "multiplexed" the several input voltages over a single input circuit.

The FET switches in this system are used in groups of three to control the record, play/source, and mute functions respectively. The input to the FET switch is its "source" terminal, the output is the "drain" terminal, and the "switch" is turned on by removing the negative bias from its "gate". The switch is "off" when the gate is more than about 4 volts negative relative to source and drain of the FET, and is "on" when the gate is at source or drain voltage. The gate never swings substantially positive relative to either source or drain, as it then becomes a forward-biased diode; any excess positive voltage swing appears across the series 1 megohm resistor.

Current will flow in either direction thru the FET while "on"; in other words the functions of "source" and "drain" are interchangeable, depending on which one is more positive than the other. In both cases, the FET resembles a resistor of about 200 ohms when "on" (gate at 0 volts), even when the gate draws no current.

Each of the coincidence switches is turned on only for the duration of its phase (5.1mS), by a positive swing of its gate. During the

other three phases, it is turned off, and any signal applied to its source at any time during those three phases produces no effect. However, whatever voltage is applied to its source during its "on" phase will be transmitted to its drain while the switch is turned on. Q1918 is turned on during Ø1, Q1911 is turned on during Ø2, and Q1910 is turned on during Ø3; none of them are on during Ø0.

Note that the sources on all three switch FETs are connected together. If a logic 1 voltage (0 volts) is applied to the sources only during Ø1, then only Q1909 will conduct it (to FF1 in IC1901) since the other two FETs are "off", and, after a few of these 5.1mS current pulses, C1912 will be discharged toward 0 volts sufficiently (approximately -8 volts) to actuate FF1 to the logic 0 state. The converse will be true if the applied voltage during Ø1 is logic 0.

As an example, let's trace the action in detail while setting channnel 1 to record, assuming that channel to be in the "no record" state to begin with. Figure 4.6-3, Flip-Flop Set/Reset Circuit, is a simplified schematic of the record assignment circuit, which should make it easier to trace this action. First, we see that during Ø1, a logic 1 voltage on J1406 pin 2 is applied thru R1918-1 to Q1909-1 to turn it on. Simultaneously, we hold the RECORD switch (S1601) actuated, and this applies a Ø1 logic 0 voltage from J1406 pin 11 thru S1601, S1606 (which is turned to position 1), and pin 8A of the line amp connector to the FET input (source). Since Q1909-1 is turned on, C1912-1 is now being charged negatively. At the end of the Ø1 period, the negative voltage is removed from the FET switch input (source). This situation is repeated during each Ø1 period as long as the RECORD switch is held actuated, and C1912-1 is quickly charged by these pulses to a voltage negative enough to force FF1 to the logic 0 state required to turn on the "record" function.

If the RECORD switch is released and the NO REC switch is then pushed, a logic 1 voltage thru D1804 (in the multiplexer card), J1406 pin 12, S1602, S1606, etc., is applied thru Q1909-1 to discharge C1912-1 impulses toward 0 volts as described earlier, and FF1 is soon reset to logic 0.

At this point it should be noted that neither the sources nor the drains of the FET switches ever reach -24 volts. At all times other than during actual switching, the drain is held at either 0 volts or about -15 volts by the associated flip-flop. The source is either

(1) held at 0 volts thru R1924,
(2) forced to 0 volts via the assignment switches,
(3) clamped to the flip-flop "in" terminal voltage during FET turn-on, or
(4) forced to about -19 (?) volts during the process of forcing the associated flip-flop to logic 0.

In explanation of this last phenomenon, it should be noted that -24 volts is applied thru R1816 (3.3K resistor in the multiplexer card) to the flip-flop input terminal with its internal resistance and -15 volts. The difference voltage (9 volts) is divided between the two

resistances; hence the -19 (?) volt limit.

The net result of the foregoing is that, while the gate is at -24 volts, it is sufficiently negative with respect to both source and drain to sustain "pinch off", and the switch is truly "off".

The Ø1 voltage, either logic 0 or logic 1, is of course applied not only to the Q1909-1 input (source), but to the inputs of Q1910-1 and Q1911-1 as well. However, the latter FET switches are turned off during this period, and therefore they are not affected.

How the output of FF1 turns the "record" function on or off and simultaneously turns the "sync" function off or on is explained later, in 4.6.4: RECORD/REPRODUCE ELECTRONICS.

The "source" and "mute" switching are done in a fashion similar to the foregoing during Ø2 and Ø3 respectively, with an additional interlocking feature. It is necessary that FF2 and FF3 (Figure 6-2) are never turned on (at logic 0) simultaneously. Thus, if the channel is in "mute" mode (FF3 at logic 0), and it is desired to switch from "play" to "source" mode, pressing the SOURCE button (S1603) will, during Ø2, switch FF2 to logic 0. However, during Ø3, the SOURCE switch will pick up a logic 1 voltage thru D1808 (multiplexer card) which will reset FF3 to logic 1 automatically. The opposite action takes place if the MUTE button is now pressed instead, returning FF2 to logic 1 during 02 and setting FF3 to logic 0 during Ø3.

To go to "play" mode, it is necessary to turn off (set to logic 1) both FF2 and FF3. By pressing the PLAY button (S1604), a logic 1 is picked up thru D1805 during Ø2, thus resetting FF2 to logic 1, and a logic 1 is picked up thru D1806 during Ø3, resetting FF3 to logic 1.

How these voltages control the associated audio circuits is explained later in 4.6.4: RECORD/REPRODUCE ELECTRONICS.

4.6.3.5 TALLY CIRCUIT.

In the lower right hand corner of Figure 6-2 are shown some of the LED tally lights for the multiplex system. For any given channel (e.g., channel 1) there are four LEDs in a vertical row, with their cathodes tied together, and driven negative by the associated transistor (Q1601) when its base is driven negative. The anodes of the four LEDs are clamped to ground potential in sequence, one at a time, during Ø0, Ø1, Ø2 and Ø3, thru transistors Q1814, Q1815/1816, Q1817 and Q1818 respectively (see 4.6.3.2). Thus, if Q1601 is turned on (base driven negative thru R1601) during Ø1, only LED I1602 will have an anode return circuit to ground during this period. The LED will glow only during Ø1, and will be dark the rest of the time. However, these light pulses occur rapidly enough (48.8 pulses per second) so that the flicker is not observable.

The top LED, I1601, indicates when the channel selector switch S1606 is turned to that channel. Only one "channel" LED will be lighted at a time (unless the Remote Electronics option is installed), since S1606 connects to only one channel at a time. With the channel selector set for channel 1, the LED driver (Q1601) will be turned on during Ø0 by a negative voltage thru D1803 (multiplexer card), J1406 pin 10, S1606 and R1601. Since I1601 is the only LED with a complete circuit to ground during Ø0, it is the only one that will glow as a result of the Ø0 signal.

The driver signals for the other three phases can come from either of two places for each phase:

(1) the channel selector switch when the appropriate assignment switch is held depressed, or
(2) from the voltage fed back from the appropriate flip-flop input terminal thru the FET switch.

If the signal is zero volts (e.g., NO REC, PLAY, or flip-flop at logic 1), the LED is not driven "on". If the signal is a negative voltage (e.g., RECORD, SOURCE, MUTE, or flip-flop at logic 0), the driver is "on" during the corresponding phase, and the LED is lighted.

For example, assuming the channel selector is turned to channel 1, pressing RECORD puts a negative voltage on the LED driver during Ø1. Simultaneously (during Ø1), Q1815 and Q1816 are clamped to ground, and LED I1602 is on. If the RECORD button is released, there will still be a negative voltage applied to the driver during Ø1, coming from the input terminal of FF1 which was just set to logic 0, thru Q1909-1 which is always turned on during Ø1.

If the channel selector is now turned to some other channel, the channel 1 LED driver will still receive the signal from FF1 during Ø1, since that is a direct circuit. The channel selector affects only the assignment switches.

4.6.4 RECORD/REPRODUCE ELECTRONICS.

This section encompasses the entire audio system, from input to tape and from tape to output, including the record and sync relays and all solid state audio switches. Figure 6-3, Schematic, Record and Play System, is provided to enable the reader to visualize and study the complete audio system.

All of the amplifiers used in the system (A1001, A1002 and A1901) are of proprietary design. Each is permanently encapsulated in an individual non-repairable plug-in component. They are identified on the schematics and parts lists by the unit series symbols and the Stephens type numbers.

There are no audio transformers in either the recording circuit or the play (monitor) circuit, and both are single-ended circuits (i.e., ground return), a fact which should be kept in mind if hum or other outside interference problems should arise.

4.6.4.1 RECORD CIRCUIT.

In the record channel, the input signal enters the system thru the line amp module, thru the REC LEVEL series pot (R1904), thru R1907, and thence to the preamp. The REC LEVEL pot R1904 with the shunt network C1905 and R1906 constitutes an adjustable voltage divider attenuator, linear over most of the audio frequency band while providing the necessary bass boost in the vicinity of 30 Hz.

In the preamp module, the signal is fed thru C1003 to the inverting input (pins 3 and 8) of the recording amplifier A1002. This is essentially a current summing point, over much of the audio frequency range, and therefore only negligble voltage appears at that point; the amplifier is actually a current-to-voltage amplifier. R1907 in the line amp module is in effect the summing resistor, and most of the audio input voltage appears across it.

The amplifier output (pins 6 and 7) is fed thru the series network of C1001, T1001 (bias coupling transformer), the record head winding (assuming the relay K1001 to be actuated), and back thru the feedback network of R1005, R1006, R1007, C1005 and C1013. The recording high frequency equalization is adjustable thru R1005.

The 204 kHz bias signal is fed to all of the preamp modules in parallel, and applied to the individual channels thru their individual record relays. In each case, the bias current is applied to the primary winding of a powder-core transformer whose secondary winding inserts the bias current in series with the amplifier output. The bias level is adjustable only by R1002, the BIAS LEVEL pot. The full bias voltage is simultaneously fed to the erase head for that channel.

The bias transformer secondary has a very low inductance, and presents a low impedance to all audio currents fed thru it to the

record head. The capacitor C1002 and transformer secondary are resonant at the bias frequency; hence their values are somewhat critical.

When K1001 is not actuated (channel is not in record mode), the record head is disconnected from the amplifier, and is instead routed to the sync relay in readiness for use as the playback head in sync mode. The resistor R1003 is substituted for the head as a load for the recording amplifier. Also, the erase head and bias transformer are grounded, to eliminate bias voltage which would otherwise leak thru due to capacitance between relay contacts.

4.6.4.2 PLAY CIRCUIT.

In the preamp module, the high gain preamplifier A1001 can receive its input from either the playback head or the record head, depending on the position of the sync relay K1002. Of course, if the channel is in record mode, the record head is disconnected from the sync relay, and therefore the sync relay must be de-energized to use the playback head. This is done automatically as explained later.

The output of the preamplifier is fed back thru a high frequency equalizing network, and thru whichever head is being used for playback, to the inverting amplifier input. This is a current summing point, with negligible voltage appearing there. The amplifier itself has a certain amount of flat negative feedback internally, to stabilize the amplifier at an appropriate maximum gain. The frequency-dependent negative feedback voltage is applied to the low side of the playback head winding, across the load resistor R1004.

The HF eq network is divided into two circuits, only one of which is used at a time, depending on whether the tape speed is set for 15 IPS or 30 IPS. The switching from one network to the other is done with diodes, as explained below.

The D.C. output of the preamplifier is approximately -12 volts, with the audio swinging slightly positive and negative from that value. Referring now to Figure 6-1, in the center of the schematic, it can be seen that, when the 30 IPS switch is released (as shown) for 15 ips operation, the "30 IPS" bus is grounded thru the tally light bulb (I402) and R409/R410 and also directly thru R407/R408. When the 30 IPS switch is activated for 30 ips operation, the "30 IPS" bus has -24 volts applied (thru R409/R410). Returning to Figure 6-3, we see that with the 30 IPS bus at 0 volts and the amplifier output at -12 volts, current flows thru D1001, D1002 and D1003 in series with R1011. This makes the diodes essentially resemble short circuits, with most of the voltage appearing across R1011. The slight current fluctuations due to the audio signal have negligible effect. Thus, C1011 and R1009 are effectively connected to the amplifier output and become part of the negative feedback circuit. The other two diodes are reverse-biased and therefore non-conducting, thus disconnecting R1010 from the circuit.

When the 30 IPS bus is at -24 volts, the diodes D1004 and D1005 are conducting, connecting R1010 into the circuit. The other three diodes are now reverse-biased, disconnecting both R1009 and C1011 from the amplifier output.

From the preamplifier output the signal is routed to the line amp module, thru C1901 and the playback level control R1901, then thru the FET switch Q1903 and C1907 to the inverting input (pins 3 and 8) of the line amplifier A1901. As with the preamplifier, this is a current summing point exhibiting virtually zero audio voltage.

The playback LF eq network consisting of R1923 and either R1903 or R1902 is shunted between the summing point and ground (assuming Q1903 is turned "on" for playback mode). For tape speed set for 15 IPS, R1903 is switched into the circuit; for 30 IPS, R1902 is connected instead. The switching is done with FET switches, controlled by the "30 IPS" bus (same one which controls the preamp eq. When the bus is at 0 volts, as for 15 IPS tape speed, the FET Q1902 is biased on, in exactly the same way as explained for the 2N5950 in 4.6.3.4: ASSIGNMENT SWITCHING; Q1902 is the same type of FET. The other FET switch, Q1901 (3N160), is a P-channel enhancement type MOS FET, which requires a substantial negative gate-to-source voltage to turn it on. This is supplied by the "30 IPS" bus when tape speed is set for 30 IPS, and the same -24 volts turns off Q1902 as explained earlier. Thus, R1902 is substituted for R1903, making the two adjustments independent of each other.

As mentioned earlier, there is a FET switch, Q1903, between the playback preamplifier and the line amplifier input. This works in conjunction with another FET switch, Q1904, to substitute a different input for the line amplifier, a signal derived from the recording input (or "source") signal. This latter signal comes directly from the recording input, is then attenuated by R1908 and R1909, and applied to Q1904. These FETs are identical to the two just described above, and function in the same way, except that they are connected in series with their respective circuits rather than to ground. With 0 volts applied to their gates, the playback circuit is on, and the "source" is off; a negative gate voltage reverses these roles. The derivation of these voltages is described later.

The line amplifier output is connected permanently to the channel VU meter, which therefore always reads the level of one of three signals:

(1) the playback head,
(2) the record head used in "sync" as a play head, or
(3) the recording input to the channel.

The amplifier output also goes thru a FET switch (Q1905) to the channel output circuit, to feed the appropriate monitor. When this switch is "off", the channel is "muted".

The control voltage to transfer from "playback" to "source", and to

actuate the "mute" function (turn off Q1905), comes from the "preset" bus. As mentioned in section 4.6.2.8: PLAY CONTROL CIRCUITS, the "pre" bus is always energized (with -24 volts) except when in "play" mode, and is energized even in that mode when the PRE switch is on. Thus, R1921 and R1922 (lower right hand corner of Figure 6-3) have -24 volts applied normally. This would transfer the line amplifier input to "source" and also mute its output, except for the fact that the logic 1 (zero volts) output of FF2 or FF3 or both, thru D1904 and D1903 respectively, inhibits one or both of switches. If both flip-flops are at logic 1, as for assignment to "play" mode (explained in 4.6.3.4: ASSIGNMENT SWITCHING), the entire -24 volt drop appears across R1921 and R1922. The FET switch gates remain at 0 volts. Q1903 is on. Q1906 has no bias voltage applied, so its collector is free to "float", and therefore Q1905 is held at 0 bias by R1913 and is therefore "on" (no "mute").

If SOURCE is assigned, FF2 goes to logic 0 (-24 volts), D1904 is reverse-biased, and the -24 volts from the "preset" bus is allowed to go thru R1922 to the gates of Q1903 and Q1904, transferring the line amplifier input to "source".

If MUTE is now assigned, FF3 goes to logic 0 and FF2 is automatically reset to logic 1, as explained in 4.6.3.4 for "source" and "mute" switching. D1904 now inhibits the "source" switching, returning the line amplifier input to source. At the same time, R1921 is no longer inhibited by D1903, and -24 volts is applied thru R1921 to the emitter of Q1906. The resulting forward bias on that transistor clamps its collector to its emitter, applying a sufficienty negative voltage to the gate of Q1905 to turn it off, thus "muting" the line amp output.

The capacitor C1911 between the drain and gate of Q1905 is there to prevent the audio voltage swings of the FET from switching it on and off.

4.6.4.3 RECORD/SYNC RELAY CONTROL.

In Figure 6-3, the record and sync relays are shown without their associated control circuitry. To understand their operation, refer to Figure 6-1, Schematic, Tape Control System. At the bottom in the right hand half of the diagram are shown portions of the preamp and line amp modules containing the control circuitry as part of the overall control system.

As explained in earlier parts of this manual, the sync function is engaged automatically, when in "record" mode, for those channels not being recorded; those channels which are actually recording must not use the sync function, for reasons stated earlier. While operating in any other mode, sync is utilized at the operator's option thru the use of the SYNC switch, S404.

Starting this description with the latter situation, we observe that -24 volts is applied thru K301 and K303 normally closed contacts to

the SYNC switch, S404. With the switch open, the voltage stops here, held at ground potential thru R413, D402 and the filament of I404. Closing the switch applies the -24 volts to the "sync" bus, thru D1902 in the line amp module to K1002 in the preamp module. FF1 in the line amp module (IC1901) has no effect, due to the high resistance of R1917 and lack of voltage at the emitter of Q1907. Also, Q1908 is ineffectual for the same reasons. Thus, all of the sync relays and none of the record relays are actuated.

With the system operating in "record" mode, the actuation of K301 removes -24 volts from the SYNC switch, defeating its ability to directly energize the sync relays, which are also disconnected from each other by all of the D1902 diodes. K301 and K302 also apply -24 volts thru D307 and D308 to the "rec" bus, and thru D1901 (in the line amp module), to the emitters of Q1907 and Q1908. Now, FF1 has control, as follows.

With FF1 at logic 1 (0 volts, "no rec"), Q1907 is clamped "on" so that its collector is at -24 volts; the sync relay actuates. The base and emitter of Q1908 are at the same potential, the collector is therefore disconnected, and the record relay is not energized.

If FF1 is at logic 0 (-24 volts), Q1907 is biased "off", disconnecting its collector, and Q1908 is biased "on" by the current thru the sync relay winding. Due to the high resistance of R1916, this current is not enough to actuate or hold the sync relay on. However, Q1908 is saturated, and actuates the record relay.

When the system is now released from the "record" mode, by going into any other mode, the release of K301 and, slightly later, of K302 removes the -24 volts from the "rec" bus, and therefore from the record and sync relays. The subsequent release of K303 restores -24 volts to the SYNC switch. The release of the sync relays which were actuated during "record" mode is very slightly delayed by their inductive current (generated by the collapse of their magnetic fields) flowing thru the D1902 diodes and D403 (at the SYNC switch).